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32	55	13	33	54	79	75	15	5	16	77	51	29	59	4	44	46	85	31	67	69	64	3	43	25	65	20	75	2	73	30	68	6	26	36	83	58	81	72

Mg	Mn	Mo	N	Na	Nb	Nd	Ni	O	Os	P	Pb	Pd	Pr	Pt	Ra	Rb	Rh	Ru	S	Sa	Sb	Sc	Se	Si	Sn	Sr	Ta	Tb	Te	Th	Ti	Tl	Tm	U	V	W	Y	Yb	Zn	Zr
76	42	47	11	82	51	61	45	1	35	12	23	41	60	37	80	84	40	39	8	63	14	56	9	18	22	78	52	66	10	24	19	27	70	49	50	48	57	71	28	21

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ERRATA

VOLUME I

PAGE

52 Thermometric Scales, Steam point. *For* 703.58°R′ *read* 671.58°R′.

68 NH_4Cl. *For* 79.2, 79.3, 79.5 % humidity *read* 79.5, 79.3, 77.5, *respectively.*

91 High Vacuum Technique, line 5. *Insert m before* = 43.74.

176 Index No. 46. *Under* Normal melting point, °C. *For* −5 *read* +2.

185 Index No. 544. *For* $C_4H_2ClN_2O_3$ *read* $C_4H_2Cl_2N_2O_3$.

193 Index No. 1084. *For* $CH_3(C_3H_7)CH_2OH$ *read* $CH_3(C_3H_7)$-CHOH.

195 Index No. 1158. *For* $C_6H_6Br_3$ *read* $C_6H_3Br_3$.

200 Index No. 1504. *For* $C_6H_8O_5$ *read* $C_6H_8O_6$; *for* Mol. wt. 160.06 *read* 176.06.

PAGE

201 Index No. 1560. *For* B.P. 196.0 *read* 166.0.

212 Index No. 2260.2. *For* Isohydroxydimethylurea *read* Isohydroxydimethyluric acid.

213 Index No. 2315. *For* $CH_2BrCONHCON(C_2H_5)_2$ *read* $(C_2H_5)_2CBrCONHCONH_2$.

226 Index No. 3066. *For* Phenylpyrazolone *read* Phenylpyrazole.

235 Index No. 3638. *Delete entry.*

251 Index No. 4612. *Delete entry.*

278 Serial No. 930. *Delete entry.*

390 **PREFERENTIAL MOTION.** First equation. *In exponent of* e *for first* z^2 *read* x^2.

ERRATA

VOLUME II

PAGE

299 *For* (2) Dellinger and Preston *31*, *read 32; and for* (3) Dellinger and Preston, *32 read 31.*

328 Table for viscosity of $CaCl_2$, second column. *For* a *read* $(\log\eta_\omega)$; *for* b *read* a; *and for* c *read* b.

PAGE

381 Index No. 1017. *In last line interchange* 450 *and* 575.

462 *In footnote* *, *for* $\alpha =$ *at read* $\alpha = \alpha_t$.

ERRATA

VOLUME III

PAGE

211 *For* Braunschweig, 1909 *read* 1919.

212 *At* 33.9°C *for* 39.6772 *read* 39.677; *and at* 34.9°C *for* 41.94 *read* 41.942.

212 *For section of Table from* 50 *to* 80°C *inclusive, insert head:*

0	1	2	etc. →	9

272 AQUEOUS SOLUTIONS OF ORGANIC COMPOUNDS. C = C_2H_6O. *In table heads for* α_{20} *read* $10^2\alpha_{20}$.

PAGE

273 AQUEOUS SOLUTIONS OF ORGANIC COMPOUNDS. C = C_2H_6O, *For* α_{20} *read* $10^2\alpha_{20}$.

310 B = C_2H_6O.—(*Continued*). In Vap. column *under* 760 mm. *for* 40.8 *read* 41; for 59.8 *read* 60; *for* 80 *read* 81; *and delete all other decimal places.*

ERRATA

VOLUME IV

PAGE

183 $C_6H_{12}O$, Cyclohexanol. *For* 3.828 *read* 38.28.

253 SUBSTITUTED PHENOLS IN WATER AT 25°C. *Add* (37) *and add* soln. *after* Equiv. per l.

ALKALOIDS IN WATER AT 20°C. *Add* (80); *cf.* (4).

ORGANIC ACIDS IN WATER AT 25°C. *Add* (37) *and add* soln. *after* Equiv. per l.

281 Cl^- SO_4^{--} Mg^{++} Na^+.—(*Continued*). *Under* t = 105°C, *insert asterisks after* H *and* I; *in line for* P, *for* 14.78 *read* 14.76; *line for* Q, *for* 67.28 *read* 54.96, *for* 54.04 *read* 64.82, *and for* 20.24 *read* 20.54.

PAGE

309 Cl^- Mg^{++} (252): $H_2O + MgO + MgCl_2$. *Add* t = 50°C.

351 SO_4^{--} Mg^{++} Na^+. *At* 103°C, *in first entry, for* 42.9m *read* 28.05m *and for* 10.31m *read* 6.73m; *in second entry, for* Na_2SO_4 *read* $3Na_2SO_4.MgSO_4$, *for* 27.92 *read* 18.24, *and for* 25.4 *read* 16.57.

394 *For* (257) Mayeda, *41 read* (257) Maeda, *142.*

459 *In* $C_5H_{17}BrO_2$, *act.*-Amyl α-bromo-*n*-butyrate, *delete question mark.*

475 *To* (13) *add* Goard, *4*, **127**: 2451; 25.

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INTERNATIONAL CRITICAL TABLES
OF
NUMERICAL DATA, PHYSICS, CHEMISTRY AND TECHNOLOGY

Prepared under the Auspices of the International Research Council and the National Academy of Sciences

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OF THE

UNITED STATES OF AMERICA

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FIRST EDITION

PUBLISHED FOR THE

NATIONAL RESEARCH COUNCIL

BY THE

McGRAW-HILL BOOK COMPANY, INC.

NEW YORK: 370 SEVENTH AVENUE

LONDON: 6 & 8 BOUVERIE ST., E. C. 4

1929

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VISCOSITY OF GASES

L. L. BIRCUMSHAW AND VAUGHAN H. STOTT

DEFINITIONS AND FORMULAE

For small velocities, the rate of shear in a gas is proportional to the shearing stress. The ratio of the latter to the former is known as the viscosity (η). The C. G. S. unit of viscosity is called the "poise."

In the case of most gases, the influence of temperature on the viscosity may be represented by the following formula due to Sutherland (1893):

$$\eta = \eta_o \frac{T_o + C}{T + C}\left(\frac{T}{T_o}\right)^{3/2},$$

where η and η_o are the viscosities at the absolute temperatures T and T_o, respectively, and C is "Sutherland's constant." C may readily be determined graphically from a number of observations by plotting T against $T^{3/2}/\eta$, since we have

$$T = \left[\frac{T^{3/2}}{\eta}\right]\left[\frac{\eta_o\left(1 + \frac{C}{T_o}\right)}{T_o^{1/2}}\right] - C$$

FLOW OF GAS THROUGH A CAPILLARY TUBE

For very small velocities, the following equation due to Meyer may be used:

$$F = \frac{\pi r^4}{16\eta l p}\left(1 + \frac{4\xi}{r}\right)(p_1^2 - p_2^2),$$

where F = volume of gas (measured at mean pressure p) flowing per second, p_1 = entrance pressure, p_2 = exit pressure, l, r = length and radius of the tube, respectively, and ξ, the slip coefficient, is approximately equal to the mean free path of the molecules.

Except at very small velocities, the above formula requires a considerable correction for kinetic energy. The corrected formula may be written, according to Brillouin (3)

$$p_1^2 - p_2^2 = \frac{p}{\rho}\left[\frac{16\eta l M}{\pi r^4\left(1 + \frac{4\xi}{r}\right)} + \frac{2M^2}{\pi^2 r^4}\right],$$

where M = the mass of gas transpired per second and ρ = the density of the gas at the mean pressure p.

Fisher (4) gives the following correction to the pressure at the entrance end due to the kinetic energy effect:

$$RT \log_e \frac{p_1}{p_1} = -\frac{1}{384}\left[\frac{p_1^2 - p_2^2}{\eta p_1 l}\right]^2 [r^4 + 12\xi^2 r^2 + 6\xi r^3],$$

where R = the gas constant, T = the absolute temperature, p_1 = the pressure to be used in Poiseuille's law, and p_1' = the manometer pressure measured in the vessel at the end of the tube. A similar formula with subscripts "2" gives the correction at the exit end.

Rapp (28) found that the following empirical formula gives the same results as Fisher's formula within the limits of experimental error:

$$\eta = \eta'\left[1 + A\frac{r^4(p_1 - p_2)}{l}\right],$$

where η is the corrected value of η'. The constant A is negative.

FLOW OF GASES THROUGH TUBES

The flow becomes turbulent when the value of $K = \rho\frac{Vd}{\eta}$ exceeds a certain value depending on the material of the tube, where ρ is the density, η the viscosity, V the velocity of the gas, and d the diameter of the tube. For practical purposes, K may be taken as >2000 for ordinary tubes.

It has been found that when due allowance is made for slip, the viscosity of a gas is independent of the pressure. The coefficient of slip between a solid and a gas depends both on the nature of the gas and on that of the solid surface [Van Dyke (39), Millikan (14) and States (35)].

In most measurements of gaseous viscosities, the value for air at a given temperature is either assumed or determined. Unless otherwise indicated, the viscosity values in the following tables have been corrected, in cases where the air value assumed or determined by the author is known, by assuming that for air $\eta_{23} = 1822.6 \times 10^{-7}$ (9) and that C = 120.

A-Table.—Elementary Substances and Atmospheric Air

Gas	t, °C	η, micropoise (10^{-6} poise)	Remarks	Lit.
A	0	209.6	C = 142	(20, 21, 22)
	23	221.0		(10)
Br_2	12.8	151		(24)
	65.7	170		
	99.7	188		
	139.7	208	C = 460	
	179.7	227		
	220.3	248		
Cl_2	12.7	129	C = 325	(23)
	99.1	168		
H_2	23	88.2	C = 72, Breitenbach; C = 83, Rayleigh	(42)
	0	84.2		
	−192.3	36.2		
	−252.5	8.5		(7)
	−257.7	5.7		
	0	(84.11)		
	+ 20.8	88.72	Down to −183°, $\eta = \eta_0\left(\frac{T}{273.1}\right)^{0.695}$;	
	−102.9	60.93		
	−183.5	39.22	p = *ca.* 400 mm	(15)
	−202.2	31.93	except for last	
	−253.06	11.10	value, where p =	
	−253.06	10.6	200 mm	

A-Table.—(*Continued*)

Gas	t, °C	η, micropoise (10^{-6} poise)	Remarks	Lit.
H_2, Vap.	B. P. (=	1.0		
H_2, Liq.	−252.7)	13.00	d = 0.0708 g/ml	(40)
He	0	187.3	C = 70	(20, 21, 22)
	23	198.1		
	23	196.23		(5, 10)
	15	108.6		
	0	186.0		
	−191.6	87.1		
	−252.6	35.0		(7)
	−257.4	27.0		
	0	(188.7)		(16)
	+ 21.43	199.4		
	− 22.8	178.8		
	− 70.0	156.4		
	−102.6	139.2		
	−184.35	91.85	$\eta = \eta_0\left(\frac{T}{273.1}\right)^{0.647}$	(16)
	−198.0	81.54		
	−252.93	35.03		
	−258.1	29.46		
Hg	273	494		(11)
	313	551		
	369	641		
	380	654		
I_2	124.0	184		(25)
	170.0	204		
	205.4	220	C = 590	
	247.1	240		
Kr	0	232.7	C = 188	(20, 21, 22)
N_2	23	176.5	C = 110.6, Bestelmeyer	(42)
Ne	0	297.3	C = 56	(20, 21, 22)
O_2	23	203.9	C = 127, Eglin	(35, 42)
Rn	0	212.4 (calc.)	C = 337 (calc.)	(20, 21, 22)
Xe	0	210.1	C = 252	(20, 21, 22)

Atmospheric air based on Harrington's value at 23° (9) and computed with C = 120; unit is 10^{-7} poise

°C	η	Dif.	°C	η	Dif.
0	1709	50	200	2582	38
10	1759	49	210	2620	38
20	1808	48	220	2658	38
30	1856	48	230	2696	37
40	1904	47	240	2733	37
50	1951	46	250	2770	36
60	1997	46	260	2806	36
70	2043	46	270	2842	35
80	2088	45	280	2877	35
90	2132	44	290	2912	34
100	2175	43	300	2946	34
110	2218	42	310	2980	34
120	2260	42	320	3014	33
130	2302	42	330	3047	33
140	2344	41	340	3080	33
150	2385	40	350	3113	33
160	2425	40	360	3146	33
170	2465	40	370	3179	33
180	2505	39	380	3212	33
190	2544	38	390	3245	32

Atmospheric air.—(*Continued*)

°C	η	Dif.	°C	η	Dif.
400	3277	32	460	3463	30
410	3309	31	470	3493	30
420	3340	31	480	3523	30
430	3371	31	490	3553	30
440	3402	31	500	3583	
450	3433	30			

No change in the viscosity of air could be detected in an electric field of 18 000 volt/cm (30). For effect of saturation with vapors, *v.* p. 6.

𝔅-Table.—Standard Arrangement

(*v.* Vol. III, p. viii)

Substance	*t*, °C	η, micropoise (10^{-6} poise)	C	Lit.
H_2O	*v.* Table 1			
HCl	12.5	138.5	357	(8)
	100.3	182.2		
HBr	18.7	181.9	375	(8)
	100.2	234.4		
HI	20.6	185.7	390	(8)
	100.2	238.3		
SO_2	0	117		(33, 41)
	18	124.2	416	
	100	161.6		
H_2S	0	116.6	331	(26)
	17	124.1		
	100	158.7		
NO	0	178		(41)
N_2O	0	135		(41)
NH_3	− 78.5	67.2		(26, 41)
	0	91.8		
	100	129.3	370	
PH_3	0	106.1	290	(26)
	15	112.0		
	100	143.8		
AsH_3	0	145.8	300	(26)
	15	114.0		
	100	198.1		
CO	−191.5	56.1		(31, 41)
	− 78.5	127		
	0	166		
	15	172	118	
	100	210		
CO_2	*v.* Table 2			
CS_2	0	91.1		(36)
	14.2	96.4		
COS	15	119.0	330	(33)
	100	154.1		
C_2N_2	0	92.8	330	(26)
	17	98.7		
	100	127.1		
SiH_4	15	112.4	229	(27)
	100	142.4		

ℭ-Table.—The ℭ-Arrangement (*v.* Vol. III, p. viii)

Formula	Name	*t*, °C	η, micropoise (10^{-6} poise)	C	Lit.
$CHCl_3$	Chloroform	0	93.6	292	(29, 36, 41)
		14.2	98.9		
		100	129		
		212.5	164		
CH_3Br	Methyl bromide	0	103		(41)
CH_3Cl	Methyl chloride	− 15.3	92	454	(2, 41)
		15.0	104		
		99.1	137		
		182.4	168		
		302.0	211		
		0	96.9		
CH_4	Methane	−181.6	34.8	198	(26, 41)
		− 78.5	76.0		
		0	102.4		
		0	102.7		
		17	108.5		
		100	135.2		
C_2H_2	Acetylene	0	93.5		(41)
C_2H_4	Ethylene	15.0	99	226	(1)
		99.3	126		
		182.4	151		
		302.0	180		
C_2H_5Cl	Ethyl chloride	0	93.7		(41)
C_2H_6	Ethane	− 78.5	63.4		(41)
		0	84.8		
C_2H_6O	Ethyl alcohol	100	108	525	(29)
		212.5	140		
C_3H_6O	Acetone	100	93.1	670	(29)
		212.5	124		
$C_3H_6O_2$	Ethyl formate	99.8	92		(18)
$C_3H_6O_2$	Methyl acetate	99.8	98	660	(18, 29)
		100	100		
		212.5	134		
C_3H_7Br	*n*-Propyl bromide	99.8	119		(18)
C_3H_7Br	Isopropyl bromide	99.8	122		(18)
C_3H_8O	*n*-Propyl alcohol	99.9	93		(18)
C_3H_8O	Isopropyl alcohol	99.8	109		(18)
$C_4H_8O_2$	Propyl formate	99.9	92		(18)
$C_4H_8O_2$	Ethyl acetate	0	68.4	650	(29); *cf.* (18, 41)
		99.8	96		
		100	94.3		
		212.5	126		
$C_4H_8O_2$	Methyl propionate	99.8	94		(18)
C_4H_{10}	*n*-Butane (1% C_2H_6)	14.7	83.2		(12)
		16.0	83.3		
		100	108.2		
C_4H_{10}	Isobutane	23	75.5		(10)
$C_4H_{10}O$	Ethyl ether	0	67.8	325	(18, 29, 36, 41)
		14.2	71.6		
		99.8	98		
		100	95.5		
		212.5	122		
$C_4H_{10}O$	Trimethyl carbinol	99.8	102		(18)

C-TABLE.—The C-ARRANGEMENT.—(*Continued*)

Formula	Name	t, °C	η, micropoise (10^{-6} poise)	C	Lit.
$C_4H_{11}N$	*n*-Butylamine	99.8	82		(18)
$C_4H_{11}N$	Isobutylamine	99.8	88		(18)
$C_4H_{11}N$	Diethylamine	99.9	92		(18)
$C_5H_{10}O_2$	Isobutyl formate	99.8	93		(18)
$C_5H_{10}O_2$	Ethyl propionate	99.9	88		(18)
C_5H_{12}	Isopentane	100 212.5	87.4 115	500	(29)
C_6H_6	Benzene	14.2 100 212.5	73.8 91.8 123	700	(29, 36)

TABLE 1.—H_2O VAPOR (34)

η in 10^{-6} poise

°C	100.0	151.2	207.1	261.3	C
η	127	145	168	190	650
°C	0	15	20.6	28.9	99.95
η (obs.)	90.4	97.5	97.5	100.6	132.0
η (extrap.)*	88	93	96	100	127

*Taking C = 650.

TABLE 2.—CO_2

η in 10^{-6} poise (39, 41)

°C	23	0	−78.5
η	147.15	137	102
C	274*	240†	

*Rankine and Smith.
†Breitenbach.

The following table for CO_2 is given by Phillips (17).

η in 10^{-6} poise; d in g/cm³

P, atm.	η	d	η/d
20°C			
83	823	0.835	986
72	771	0.812	950
59	697	0.768	907
56	186	0.190	977
50	177	0.145	1220
40	166	0.100	1660
20	156	0.036	4330
1	148	0.00183	80800
30°C			
110.5	770	0.795	968
104	733	0.781	939
96	693	0.760	913
90	643	0.743	864
82	592	0.716	827
80	565	0.706	800
76	529	0.680	778
74	495	0.664	745
73	478	0.653	732
72	458	0.635	723
70	229	0.287	798
60	187	0.177	1057
40	168	0.092	1830
20	159	0.0354	4500
1	153	0.00177	86400

TABLE 2.—CO_2.—(*Continued*)

P, atm.	η	d	η/d
32°C			
120	788	0.790	998
112	741	0.777	954
104	695	0.760	914
93	627	0.729	860
87	586	0.700	837
84	560	0.682	822
80	528	0.655	807
76	448	0.597	751
75	406	0.555	730
74	254	0.360	700
70	214	0.255	840
60	187	0.170	1100
40	175	0.090	1950
20	162	0.0352	4600
1	155	0.00176	88100
35°C			
114.5	693	0.755	918
109	660	0.741	891
96	586	0.696	841
88	511	0.653	782
85	456	0.626	728
80	361	0.494	731
75	237	0.289	820
70	214	0.227	943
60	178	0.163	1091
40	174	0.085	2045
20	163	0.0348	4680
1	156	0.00174	89600
40°C			
112	571	0.699	817
108	540	0.682	792
100	483	0.636	761
94	414	0.582	712
85	269	0.385	698
80	218	0.291	748
70	200	0.204	981
60	187	0.153	1220
40	176	0.083	2120
23.8	169	0.0408	4140
1	157	0.00173	90800

GAS MIXTURES

A-B TABLE.—STANDARD ARRANGEMENT

He − H_2

η in micropoises (10^{-6} poise) (5)

% He	% H_2	η Calc.	η Obs.	t, °C	C
100.1 (*sic.*)	0.0	189.09	189.25	0.00	
		195.46	195.36	13.37	71.4
		234.08	234.10	100.05	
96.094	3.906	184.60	185.00	0.0	
		192.17	191.77	15.93	73.9
		228.95	229.07	100.22	
89.559	10.431	176.00	175.96	0.0	
		182.02	182.14	12.63	89.8
		220.36	220.33	100.02	
86.400	13.600	172.35	173.27	0.0	
		180.10	179.29	16.86	85.7
		215.27	215.57	100.05	

A-B Table.—(*Continued*)

% He	% H_2	η Calc.	η Obs.	t, °C	C
75.087	24.913	159.71	160.32	0.0	
		166.35	165.67	15.86	77.8
		198.35	198.47	99.67	
59.716	40.284	142.52	143.06	0.0	
		148.14	147.55	14.67	87.75
		178.23	178.40	99.80	
39.857	60.143	122.24	122.67	0.0	
		127.00	126.53	15.03	75.50
		151.73	151.77	100.09	
18.807	81.193	101.56	101.65	0.0	
		106.09	106.01	17.0	80.63
		126.48	126.50	100.15	
0.0	100.00	84.10		0.0	
		87.40	87.72	14.79	83.0
		104.95	104.60	100.5	

$O_2 - H_2$

11.1°C (6)	% O_2	100	97.5	95	90	75	0
	$\eta_{rel.}$	1	0.9957	1.000	0.9946	0.9724	0.4502

$O_2 - N_2$

12.2°C (6), η (for 100% O_2) = 1

% O_2	$\eta_{rel.}$	% O_2	$\eta_{rel.}$	% O_2	$\eta_{rel.}$
97.5	0.9984	66.6	0.9550	10	0.8847
95	0.9941	50	0.9348	5	0.8804
90	0.9871	33.3	0.9138	2.5	0.8847
75	0.9734	25	0.9051	0	0.8750

$O_2 - CO$

η_{O_2} at $t° = 1$ (6)

12.2°C	% O_2	100	25	10	5	2.5	0
	$\eta_{rel.}$	1	0.9040	0.8842	0.8757	0.8743	0.8701
11.1°C	% O_2	100	75	66.7	50	33.3	0
	$\eta_{rel.}$	1	0.9666	0.9593	0.9361	0.9129	0.8664

$O_2 - CO_2$

η_{O_2} at $t° = 1$ (6)

13.3°C	% O_2	100	50	25	10	5	2.5	0
	$\eta_{rel.}$	1	0.8714	0.8071	0.7679	0.7559	0.7538	0.7464
12.2°C	% O_2	100	97.5	95	90	75	0	
	$\eta_{rel.}$	1	0.9943	0.9872	0.9759	0.9420	0.7510	

$O_2 - CH_4$

η_{O_2} at $t° = 1$ (6)

12.8°C	% O_2	100	50	25	10	5	2.5	0
	$\eta_{rel.}$	1	0.8076	0.6902	0.5983	0.5827	0.5770	0.5629

$H_2 - SO_2$ (38)

17°C		45°C		70°C		92°C	
% H_2	$\eta \times 10^7$	% H_2	$\eta \times 10^7$	% H_2	$\eta \times 10^7$	% H_2	$\eta \times 10^7$
0.00	1241	0.00	1366	0.00	1476	0.00	1576
17.85	1274	19.72	1404*	19.72	1513	19.72	1609
49.25	1330	49.25	1453	30.01	1534	30.01	1624
70.37	1350	70.37	1472	38.25	1551	38.25	1651
77.14	1324	77.14	1431	51.77	1564	51.77	1657
83.24	1285	83.24	1389	70.37	1573	76.94	1616
100.00	875	100.00	931	76.94	1528	83.43	1554*
				83.43	1483	83.24	1550*
				83.24	1478*	100.00	1022
				100.00	979		

$H_2 - SO_2$.—(*Continued*)

124°C		153°C		199°C	
% H_2	$\eta \times 10^7$	% H_2	$\eta \times 10^7$	% H_2	$\eta \times 10^7$
0.00	1714	0.00	1869	0.00	2041
32.40	1751	32.40	1914	32.40	2087
53.02	1787	53.02	1931	50.95	2090
67.35	1775	67.35	1914	67.35	2068
83.64	1660	83.24	1777	84.88	1924
100.00	1086	84.88	1722	100.00	1219
		100.00	1152		

* For these values the temperature reading was obtained by interpolation over more than 5°C.

$H_2 - N_2$

12.8°C (6), $\eta_{rel.}$ to $O_2 = 1$	% H_2	100	50	0
	η_{rel}	0.04493	0.8014	0.8690

$H_2 - N_2O$

11.1°C (6), $\eta_{rel.}$ to $O_2 = 1$	% H_2	25	10	0
	η_{rel}	0.7510	0.7481	0.7481

$H_2 - NO$

11.1°C; values of % H_2 and of η relative to $O_2 = 1$ (6)

100%	75%	50%	25%	10%	5%	0%
0.4482	0.7159	0.8224	0.8491	0.8609	0.8788	0.8661

$H_2 - NH_3$

12–13°C; values of % H_2 and of η in 10^{-7} poise (37)

0.0%	8.2%	20.1%	33.9%	53.6%	68.4%	79.1%	90.2%	100.0%
1005	1017	1042	1068	1102	1104	1089	1036	915

$H_2 - CO$

11.1°C; $\eta_{rel.}$ to $O_2 = 1$ (6)

% CO	100	95	92.5	90	75	0
η_{rel}	0.8664	0.8650	0.8635	0.8650	0.8432	0.4586

$H_2 - CO_2$

Values of % H_2 and of $\eta_{rel.}$ to $O_2 = 1$ (6)

12.8°	100%	25%	10%				
	0.4493	0.7535	0.7521				
12.2°	100%	97.5%	95%	90%	75%	50%	0%
	0.4321	0.4983	0.5157	0.5722	0.6786	0.7339	0.7470

η in 10^{-7} poise

% H_2 (19)*	14.7°	% H_2 (19)*	14.7°	% H_2 (1)	15°	99.2°	% H_2 (37)	15°
0.0	1468	90.16	1215	0.0	1464	1869	0.0	1468
9.97	1477	93.58	1111	12.98	1484		8.5	1483
19.85	1491	96.12	1031	15.56		1897	17.2	1490
27.75	1499	97.60	991	14.99		1880	22.4	1493.5
56.54	1475	98.32	958	48.44	1485	1805	55.4	1485
73.59	1399	100	893	82.20	1289	1624	66.7	1450
83.92	1307			97.24	991	1195	76.5	1367
				100	893	1064	82.2	1292
							87.9	1901

* Not corrected to standard air value.

$H_2 - CH_4$

Values of % H_2 and of $\eta_{rel.}$ to $O_2 = 1$ (6)

12.2°	100%	17.5%	10%	5%	2.5%	0%	
	0.4497	0.5572	0.5629	0.5615	0.5502	0.5544	
12.8°	100%	97.5%	95%	90%	75%	50%	0%
	0.4616	0.4714	0.4797	0.4965	0.5313	0.5596	0.5481

$H_2 - C_2H_4$

12–13°; η in 10^{-7} poise (37)

% H_2	0.0	27.1	45.6	63.0	72.6	83.0	92.4	100.0
η	1016	1048	1078	1087	1086	1062	1008	915

$NH_3 - C_2H_4$

12–13°; η in 10^{-7} poise (37)

% NH_3	0.0	8.0	17.5	27.5	42.0	58.9	81.3	100.0
η	1016	1037	1043	1047	1050	1046	1028	1005

Air – H_2

16.1°C (6)

% H_2	100	95	90	75	25	0
$\eta_{rel.}$ (O_2 = 1)	0.4434	0.5282	0.5880	0.7488	0.8790	
$\eta_{rel.}$ (air = 1)	0.4927	0.5869	0.6534	0.7987	0.9767	1

16.4°C	% H_2	50	10	5	0
	$\eta_{rel.}$ (O_2 = 1)	0.8197	0.8888	0.8960	
	$\eta_{rel.}$ (air = 1)	0.9108	0.9876	0.9956	1

Air – H_2O

Saturated at 26°; $10^7\eta$ = 1904 (air = 1863) (13). Stearns (35.1) claims that the viscosity of air is *decreased* by saturating it with moisture, the decrease being ⅓ % at 760 mm and 35 % at 14 mm pressures.

Air – C_2H_4

η in 10^7 poise; not corrected to standard air value (1)

% C_2H_4	100	90.3	69.0	54.6	30.0	13.6	0.0
η (15°)	1011	1078	1236	1345	1548	1692	1809
η (99.3°)	1282	1367		1674		2069	2209

Air – C_2H_5OH

Saturated at 26°; $10^7\eta$ = 1878 (air = 1863) (13).

LITERATURE

(For a key to the periodicals see end of volume)

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(40) Verschaffelt, *64P*, **20**: 986; 18. *168*, No. **153b**; 18. (41) Vogel, *8*, **43**: 1235; 14. (42) Yen, *3*, **38**: 582; 19.

VISCOSITY OF METALS AND ALLOYS

W. Rosenhain, Editor

Definitions and Meanings of Symbols

S_e Tensile stress.
S_g Shearing stress.
e Unit elongation.
g Shear.
E Young's modulus of elasticity.
G Modulus of rigidity.
ξ "Normal" coefficient of viscosity.
η Tangential coefficient of viscosity.
δ Logarithmic decrement of damped vibrations.

The coefficients of elasticity and viscosity of an isotropic solid body are defined by the equations:

$$S_e = Ee + \xi\frac{de}{dt}$$

$$S_g = Gg + \eta\frac{dg}{dt}$$

The coefficient of viscosity of a liquid is defined by:

$$S_g = \eta\frac{dg}{dt}$$

The physical significance is different, however, the order of magnitude being 10^{-12} that for a solid.

The logarithmic decrement is the logarithm of the ratio of two successive maximum displacements, on the same side of the equilibrium configuration.

Note.—For material possessing no symmetry whatever, there are 21 elastic and 36 viscous constants, which are coefficients in the six linear equations giving the six stress components in terms of the six strain components and their time derivatives. The constants in the following tables have been computed on the assumption that the material is isotropic, though this is admittedly not the case in unannealed wires and possibly not in the other materials investigated.

In general, the coefficients of viscosity computed on this basis from the logarithmic decrement of vibrations, increase linearly with the amplitude of vibration. This may be due either to "after-effect" or to the fact that terms quadratic in the strain-velocities are necessary completely to define the stress components in terms of the strain components. For a discussion of the theory, *see* (11). The values of the coefficients for an amplitude of $\theta°$ are designated by ξ_θ and η_θ.

The values of the coefficients of viscosity of solid metals and alloys depend not only upon their chemical composition but very largely on their condition, especially their microstructure. The values given below are to be applied only to material in the same condition and only to specimens whose size is of the same order of magnitude as the specimens for which the results are given.

VISCOSITY OF SOLID METALS AND ALLOYS

F. P. Upton

"Normal" Coefficient of Viscosity for Zero Amplitude at Room Temperature, cgs Units

Determined from damping of flexural vibrations of rectangular strips

Material	Treatment	Dimensions, cm l	m	n	Period, sec	$10^{-8}\xi_0$	Lit.*
Ag	Hammered	26.0	0.500	0.104	0.731	2.85	(5)
	Annealed at 400°C.	26.0	0.500	0.104	0.719	2.24	
Al	Rolled	26.0	0.719	0.0999	0.709	0.75	(5)
	Rolled	26.0	0.372	0.0997	0.798	0.82	
	Annealed at 400°C.	26.0	0.719	0.0999	0.716	1.25	
Cd	Cast	†	†	†	0.684	0.165‡	(11)
	Cast				0.934	0.257‡	
	Cast	†	†	†	0.892	8.0§	(11)
	Cast				1.220	11.4§	
Cu	Rolled	26.0	0.380	0.134	0.586	4.86	(5)
	Rolled	26.0	0.380	0.134	0.838	5.11	
	Rolled	26.0	0.373	0.049	0.903	4.68	
	Annealed at 300°C.	26.0	0.380	0.134	0.610	5.16	
	Cast	†	†	†	0.708	0.29‖	(11)
Cu-Sn-P	Cast	†	†	†	0.537	0.41‖	(11)
	Cast				1.010	0.34‖	
Cu-Zn	Cast	†	†	†	0.732	0.23¶	(11)
Cu, 60; Zn, 40	Rolled	26.0	0.354	0.155	0.535	1.55	(5)
Fe-C, 0.18	Unannealed	26.0	0.489	0.0726	0.750	4.94	(5)
	Annealed				0.756	2.68	

"Normal" Coefficient of Viscosity.—(*Continued*)

Material	Treatment	Dimensions, cm l	m	n	Period, sec	$10^{-8}\xi_0$	Lit.*
Fe-C, 0.38	Unannealed	26.0	0.497	0.0892	0.688	5.12	(5)
	Annealed				0.684	3.51	
Fe-C, 0.67	Unannealed	26.0	0.500	0.123	0.479	5.93	(5)
	Annealed				0.481	4.30	
Fe-C, 1.17	Unannealed	26.0	0.497	0.0811	0.708	5.06	(5)
	Annealed				0.701	4.27	
Fe-C, 1.75	Unannealed	26.0	0.480	0.0725	0.766	7.20	(5)
Fe-C	Cast (steel)	†	†	†	0.508	1.25**	(11)
					0.724	1.58**	
Fe-C	Cast (iron)	†	†	†	0.480	3.6††	(11)
					0.641	6.0††	
Mg	Hammered	26.0	0.500	0.120	0.751	1.61	(11)
	Annealed at 400°C.				0.755	0.722	
Ni	Rolled	26.0	0.497	0.105	0.550	3.05	(5)
	Cast	†	†	†	0.553	0.96‡‡	(11)
Zn	Rolled	26.0	0.356	0.0669	0.978	27.4	(5)
	Annealed at 200°C.				0.883	9.27	

* Results of (5) were each obtained from damping of vibrations *in vacuo* of a strip loaded at lower end. Results of (11) were each obtained from damping of vibrations of a strip fixed at one end and at the other attached to a heavy disk rotatable in the plane of flexure, the plane of strip when unstrained passing through axis of disk. In (11) only values of $\frac{\xi_0}{E}$ were given. Values of ξ are computed from values of E given below.

In (5) $\delta = \frac{mn^3T}{8Ml^3}\xi$, where M is mass of load and T is period ($\frac{1}{2}\delta$ is called log decrement in the original). In (11) $\delta = \frac{mn^3T}{4M'l^3}\xi$ where M' is mass of heavy disk. The results in this table are not corrected for effect of non-rigidity of support. For methods, *v.* (16). For more recent data, *v.* (17).

† Average dimension of strips, 10 × 0.6 × 0.1 cm.

‡ Assumed E = 6 570 kg/mm².

§ Assumed E = 7 070 kg/mm².

‖ Assumed E = 10 800 kg/mm².

¶ Assumed E = 9 400 kg/mm².

** Assumed E = 20 750 kg/mm².

†† Assumed E = 9 000 kg/mm².

‡‡ Assumed E = 20 300 kg/mm².

Tangential Coefficient of Viscosity for Zero Amplitude (6)

Determined from damping of torsional vibrations of annealed wires; for effect of temperature, *v.* Figs. 1–10

Material	*t*, °C	Length, cm	Radius, cm	Period, sec	$10^{-8}\eta$*
Ag	13	25.5	0.0285	9.671	12.50
Al	15	25.5	0.0315	7.035	25.50
Au	15	25.5	0.0280	9.603	17.00
Cu	22	25.7	0.0275	6.899	6.70
Fe	16	25.4	0.0295	5.744	12.89
Fe-C, 0.55	22	25.6	0.0290	5.684	12.90
Fe-C, 0.9	16	23.7	0.0335	5.693	7.70
Fe-C, 1.30	19	25.5	0.0275	6.670	9.82
Ni	16	25.5	0.0250	6.521	1.65
Pt	15	25.6	0.0240	8.198	1.75
Pt, 85; Rh, 15	17	25.5	0.0195	10.059	4.19
W	16	25.5	0.0215	7.625	9.37
Zn	22	25.5	0.0270	8.642	410.7

* $\delta = \frac{\pi R^4 T}{4Il}\eta$, where R = radius of wire, l = length of wire, T = period, I = moment of inertia of load ($\frac{1}{2}\delta$ is called log decrement in the original paper, and tabulated values are $\log_{10}$); η in poises.

VISCOSITY OF LIQUID METALS AND ALLOYS

C. H. M. Jenkins (CHMJ), N. E. Dorsey (NED), O. F. Hudson (OFH), T. K. Rose (TKR)

% Composition	*t*, °C	100η
Bi, 100 (13)	304	1.662
	451	1.280
	600	0.998
Bi, 77.88; Sn, 22.12	306	1.682
	444	1.318
	600	1.049
Bi, 58.0; Sn, 42.0	305	1.690
	445	1.267
	606	1.014
	751	0.886
Bi, 46.82; Sn, 53.18	303	1.642
	399	1.336
	444	1.234
	601	1.003
	750	0.881
Cd, 100 (1) (CHMJ)	349	1.44
	406	1.34
	466	1.27
	506	1.18
	550	1.15
	603	1.10
Cu, 100 (14)	1145	3.41
	1179	3.19
	1187	3.25
Cu, 85; Sb, 15 (14)	1008	3.77
	1108	3.28
Cu, 72; Sb, 28 (14)	737	6.73
	895	4.42
	998	3.60
	1090	3.08
Cu, 61.34; Sb, 38.66 (14)	786	5.41
	890	4.02
	998	3.24
	1003	3.23
	1090	2.82
Cu, 56.94; Sb, 43.06 (14)	797	4.69
	790	4.71
	895	3.72
	989	3.14
	1087	2.66
Cu, 61.64; Sn, 38.36	803	5.609
Cu, 82.0; Sn, 18.0 (14)	1025	3.62
	1110	3.26
Cu, 71.0; Sn, 29.0 (14)	898	4.34
	1001	3.56
Cu, 61.64; Sn, 38.36 (14)	799	5.19
	900	3.93
	1005	3.16
	1096	2.74
Cu, 50.0; Sn, 50.0 (14)	755	3.65
	903	2.69
	1005	2.28
Fe, 97.5; C, 2.5 (15)	1400	2.25
	1350	2.65
Fe, 97; C, 3.0 (15)	1400	2.025
	1350	2.375
	1300	2.800
Fe, 96.5; C, 3.5 (15)	1400	1.75
	1350	2.00
	1300	2.40
	1250	2.90
Fe, 96.0; C, 4.0	1400	1.45
	1350	1.55
	1300	1.75
	1250	2.10
Hg, 100 (2, 4, 8, 10, 12) (NED)*	−20	1.85
	0	1.68
	+20	1.55
	50	1.39
	100	1.21
	150	1.09
	200	1.01
	250	0.96
	300	0.92
	350	0.90
Hg, 98; Cd, 2 (10) (TKR)	14.5	1.679
	20	1.652
	40	1.551
Hg; Cu (10) (TKR)	10	1.671
	20	1.620
	40	1.520
Hg, 99; Pb, 1 (10) (TKR)	13	1.664
	20	1.627
	30	1.586
	48	1.511
Hg, 99.4; Zn, 0.6 (10) (TKR)	13	1.672
	20	1.639
Pb, 100 (14)	441	2.116
	456	2.059
	551	1.700
	703	1.349
	844	1.185
Pb, 51.3; Bi, 48.7	403	1.571
	543	1.276
	682	1.100
	833	0.977
Pb, 70.0; Bi, 30.0	403	1.728
	413	1.668
	543	1.370
	704	1.145
	852	1.021
Pb, 90; Bi, 10	545	1.522
	550	1.526
	704	1.274
	840	1.114
	867	1.100
Pb, 83.05; Sb (9) (OFH)	292	2.768
84.60	292	2.579
87.03	292	2.355
89.98	292	2.413
92.39	292	2.654

* $1/\eta = 59.40 + 0.264t - 0.000341t^2$ (2, 4, 8, 10, 12). At p = 1500 atm., η is 4.8 % greater than at 1 atm. (3).

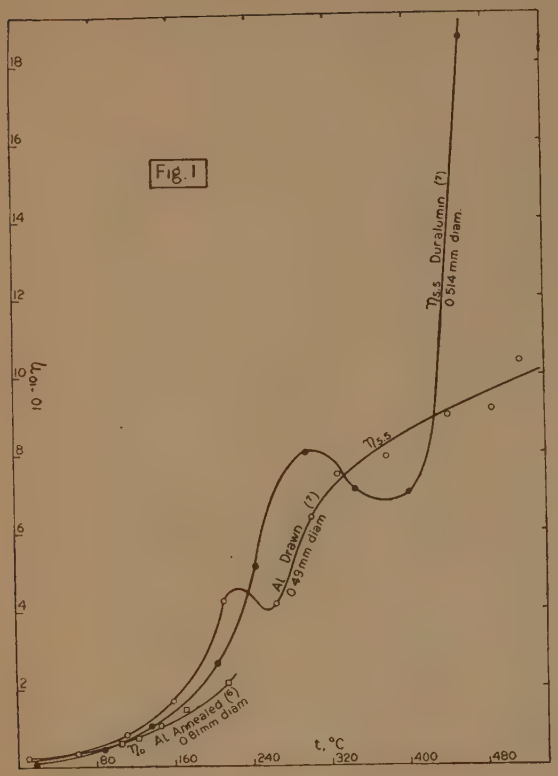
Fig. 1
$\eta_{s.s}$ Duralumin (7)
0.514 mm diam.
$\eta_{s.s}$
Al Drawn (7)
0.49 mm diam
η_0 Al Annealed (6)
0.81 mm diam
$10^{-10}\eta$
t, °C

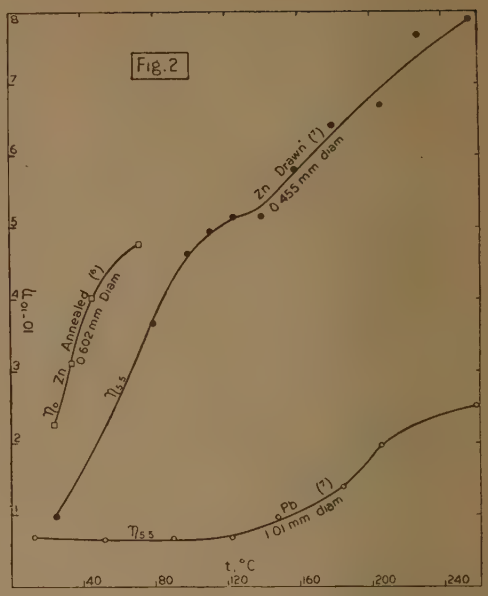
Fig. 2
Zn Drawn (7)
0.455 mm diam
η_0 Zn Annealed (6)
0.602 mm Diam
$\eta_{s.s}$
Pb (7)
1.01 mm diam
$10^{-10}\eta$
t, °C

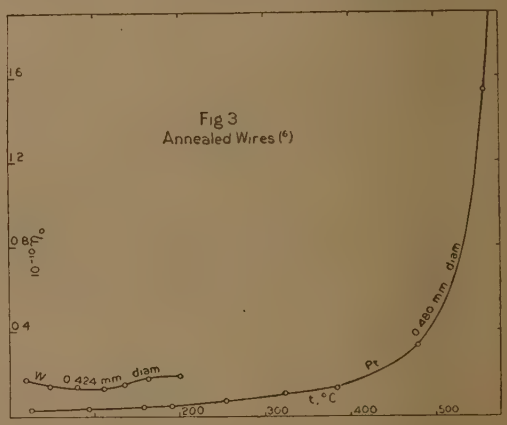
Fig 3
Annealed Wires (6)
W 0.424 mm diam
Pt
0.480 mm diam
$10^{-10}\eta_0$
t, °C

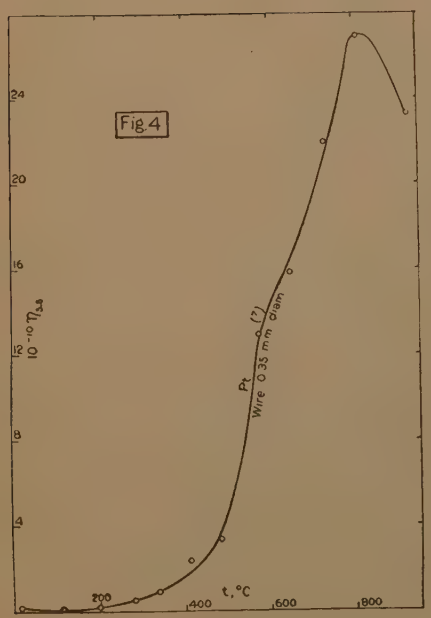
Fig. 4
Pt (7)
Wire 0.35 mm diam
$10^{-10}\eta_{s.s}$
t, °C

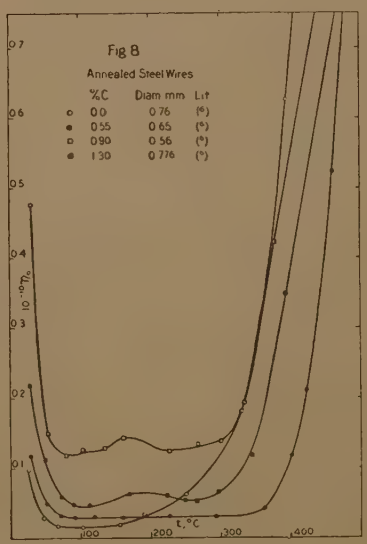
Fig 8
Annealed Steel Wires
%C Diam mm Lit
0.0 0.76 (6)
0.55 0.65 (6)
0.90 0.56 (6)
1.30 0.776 (6)
$10^{-10}\eta_0$
t, °C

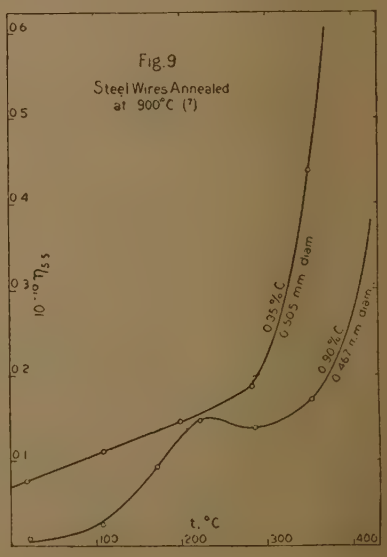
Fig. 9
Steel Wires Annealed
at 900°C (7)
0.35 % C
0.505 mm diam
0.90 % C
0.467 mm diam
$10^{-10}\eta_{s.s}$
t, °C

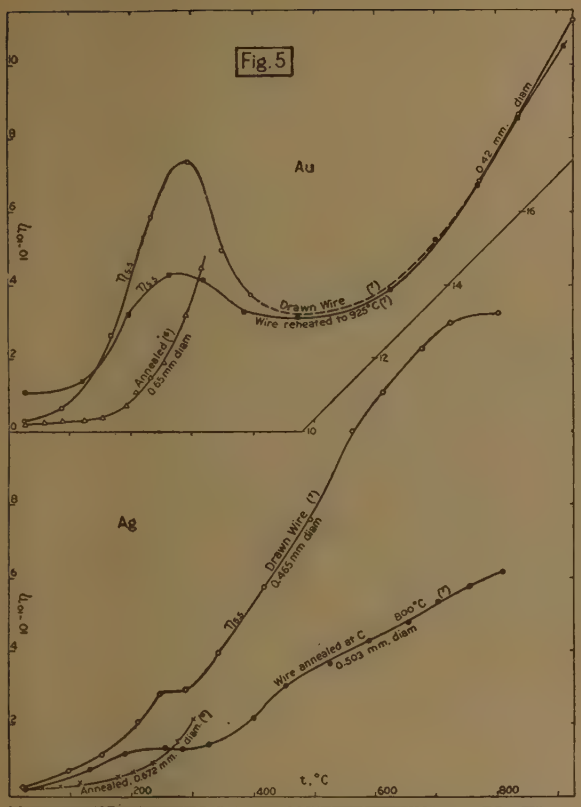
Fig. 5
Au
Drawn Wire (*)
Wire reheated to 925°C (*)
0.42 mm. diam
Annealed (*) 0.65 mm diam
Ag
Drawn Wire (*) 0.485 mm diam
Wire annealed at C 800°C (*)
0.503 mm. diam
Annealed 0.672 mm. diam (*)
t, °C

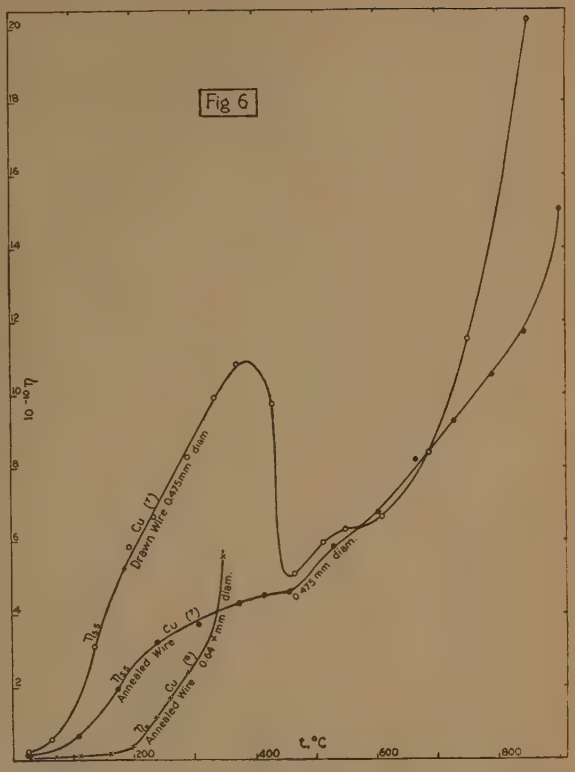
Fig 6
Cu (*)
Drawn Wire 0.425mm diam
0.475 mm diam.
Annealed Wire
Cu (*)
0.64 mm diam.
Annealed Wire 0.64 mm diam
t, °C

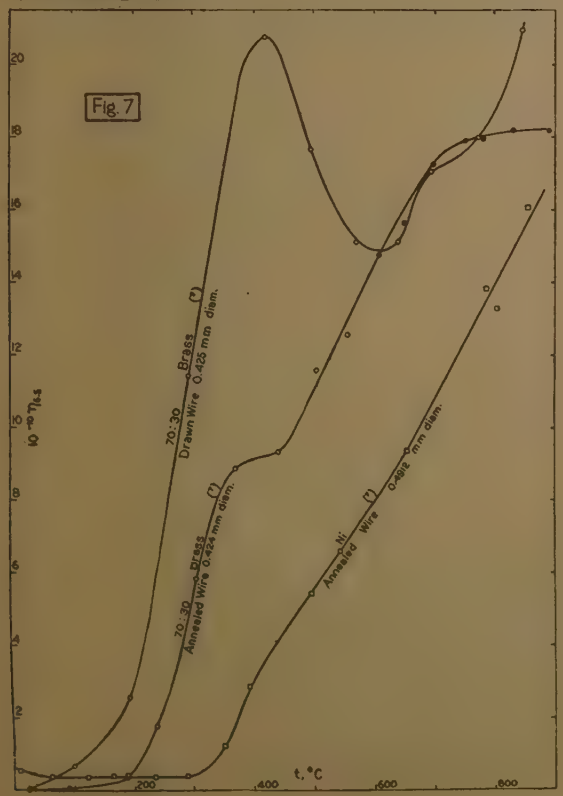
Fig. 7
70:30 Brass (*)
Drawn Wire 0.425 mm diam.
70:30 Brass (*)
Annealed Wire 0.424 mm diam.
Ni (*)
Annealed Wire 0.492 mm diam.
t, °C

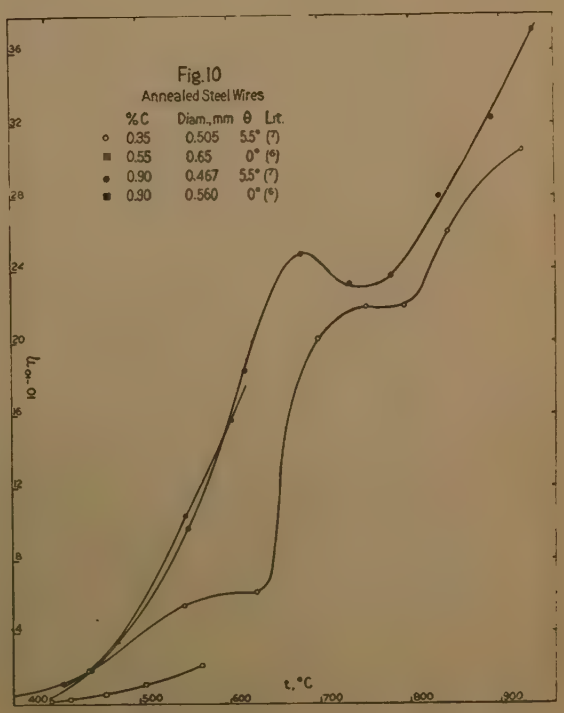
Fig.10
Annealed Steel Wires
%C Diam., mm θ Lit.
0.35 0.505 5.5° (7)
0.55 0.65 0° (8)
0.90 0.467 5.5° (7)
0.90 0.560 0° (8)
t, °C

% Composition	t, °C	100η
Pb, 5.02; Sn [9] (OFH)	280	1.706
9.29	280	1.746
15.54	280	1.830
19.55	280	1.919
30.31	280	2.066
32.99	280	2.052
36.08	280	1.965
39.21	280	2.053
49.38	280	2.189
64.27	280	2.349
69.80	280	2.451
79.57	280	2.716
Sb, 100 [14]	702	1.304
	801	1.113
	902	1.010
	1002	0.905

% Composition	t, °C	100η
Sb, 57.0; Cu, 43.0	715	2.93
	802	2.47
	900	2.12
	998	1.867
	1096	1.683
Sb, 76.0; Cu, 24.0	644	1.886
	804	1.483
	903	1.304
	1011	1.176
Sn, 100 [9] (OFH)	280	1.678
	296	1.664
	357	1.421
	389	1.311
Sn, 100 [13]	301	1.680
	320	1.593
	351	1.518
	450	1.270

% Composition	t, °C	100η
Sn, 100—(*Cont'd*)	604	1.045
	750	0.905

% Composition	t, °C	100η
Sn, 75.0; Cu, 25.0 [14]	685	1.833
	830	1.510
	1001	1.266

LITERATURE

(For a key to the periodicals see end of volume)

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[10] von Schweidler, *75*, **104** IIa: 273; 95. [11] Voigt, *8*, **47:** 671; 92. [12] Warburg, *8*, **20:** 367; 70. [13] Sauerwald and Töpler, *93*, **157:** 117; 26., [14] Bienias and Sauerwald, *93*, **161:** 51; 27. [15] Thielmann and Wimmer. *77*, **47:** 389; 27. [16] Chevenard and Portevin, *378*, **1926 Spec. No.** 434 [17] Hettwer, *75*, **134** IIa: 51; 25.

VISCOSITY OF WATER, SULFURIC ACID, LIQUID CARBON DIOXIDE AND CERTAIN ORGANIC LIQUIDS*

N. Ernest Dorsey

Formulae and Units

At a pressure of 1 atm., $\eta = a/(b + t)^n$.
At a pressure of P kg/cm², $\eta_P = \eta_1[1 + k_t(P - 1) \times 10^{-4}]$.
η_1 is the value of η when P is 1 kg/cm², which may be taken as the value of η at 1 atm.
The unit of η is the poise unless otherwise stated.

Water between 0 and 100°. I. C. T. Values

The following table was prepared from a critical evaluation of all available data. It is estimated that the accuracy is of the order of 0.1% between 0 and 40° and of 0.5 to 1% at higher temperatures. Linear interpolation may be safely employed throughout the table.

Values in millipoises [1, 12, 16, 17, 22, 24, 30, 31, 32, 38]

t, °C	0	1	2	3	4	5	6	7	8	9
0	17.938	17.320	16.740	16.193	15.676	15.188	14.726	14.288	13.872	13.476
10	13.097	12.735	12.390	12.061	11.748	11.447	11.156	10.875	10.603	10.340
20	10.087	9.843	9.608	9.380	9.161	8.949	8.746	8.551	8.363	8.181
30	8.004	7.834	7.670	7.511	7.357	7.208	7.064	6.925	6.791	6.661
40	6.536	6.415	6.298	6.184	6.075	5.970	5.868	5.770	5.675	5.582
50	5.492	5.405	5.320	5.236	5.153	5.072	4.994	4.918	4.843	4.770
60	4.699	4.629	4.561	4.495	4.431	4.368	4.306	4.245	4.186	4.128
70	4.071	4.016	3.962	3.909	3.857	3.806	3.756	3.708	3.661	3.615
80	3.570	3.526	3.483	3.440	3.396	3.357	3.317	3.278	3.240	3.203
90	3.166	3.130	3.095	3.061	3.027	2.994	2.962	2.930	2.899	2.869
100	2.839	2.82	2.79	2.76	2.73	2.70	2.67	2.64	2.62	2.59

H_2O below 0°C [39]

Values corrected and adjusted to accord with I. C. T. values above 0°C

t, °C	−2	−4	−5	−6	−8	−10
1000η	19.1	20.5	21.4	22.2	24.0	26.0

H_2O above 100°C [16]

Values as recorded by author accord with I. C. T. values below 100°C; the others are given as he has published them. The pressure is that of the saturated vapor at the temperatures indicated.

t, °C	110	120	130	140	150	160
1000η	2.56	2.32	2.12	1.96	1.84	1.74

H_2O: Variation with Pressure

Unit of P = 1 kg/cm²

t, °C	0	10.3	30	75	P	t	k_t	Lit.
P	k_t [3]							
					23.8	9	−2.0	[28]
500	−1.24	−0.62	+0.49	+0.72	100	1	−2.14	[4]
1 000	−0.79	−0.46	+0.53	+0.76	300	1	−1.28	[4]
1 500	−0.45	−0.29	+0.57	+0.75	600	1	−1.05	[4]
2 000	−0.215	−0.160	+0.64	+0.81	100	15	−0.55	[4]
3 000	+0.080	+0.051	+0.76	+0.84	200	15	−0.63	[4]
4 000	+0.278	+0.202	+0.87	+0.90	300	15	−0.51	[4]
5 000	+0.44	+0.332	+0.95	+1.00	400	15	−0.54	[4]
6 000	+0.58	+0.43	+1.02	+1.09	500	15	−0.46	[4]

* For main section of Viscosity of Pure Liquids, *see* final index.

H_2O: Variation with Pressure.—(*Continued*)

t, °C	0	10.3	30	75
P	k_t (3)			
7 000		+0.52	+1.07	+1.17
8 000		+0.60	+1.12	+1.25
9 000			+1.16	+1.36
10 000			+1.17	
11 000			+1.19	

P	t	k_t	Lit.
600	15	−0.39	(4)
700	15	−0.33	(4)
900	15	−0.30	(4)
100	23	−0.47	(4)
300	23	−0.25	(4)
600	23	−0.17	(4)
413	20	−0.33	(14)
310	50 to 80	+0.4	(14)
362	55	+0.6	(14)
516	40	+0.4	(14)

Variation of k_t with t, P = 413 kg/cm² (14)

t, °C	20	30	40	50
k_t	−0.33	−0.07	+0.17	+0.34
t, °C	60	70	80	90
k_t	+0.48	+0.62	+0.73	+0.82

In disagreement with the preceding data, the observations of (29, 37) indicate that at 20°C and pressures not exceeding 150 kg/cm², $k_t = -1.7$.

Sulfuric Acid

$\eta = \frac{1}{3(1 - 0.0075t - 0.001t^2)}$ if t lies between 11 and 90°C (5, 6, 7, 8, 25, 26). The observations are discordant by ±5% and more; the composition of the acid is indefinite but presumably between 98 and 100%. At 0°, η is 45% greater than that given by the formula (5); *cf.* (19); there is only one recorded observation at 0° and none between 0 and 11°.

t, °C	0	11	15	20	30	40	50	60	70	80	90
$10^3\eta$	484	321	299	267	199	145	107	80	62	49	40

Liquid Carbon Dioxide

Under essentially the pressure of its saturated vapor (36)

t, °C	5	10	15	20	25	29
p, atm	40.4	45.7	51.6	58.2	65.6	73.6
$10^3\eta$	0.925	0.852	0.784	0.712	0.625	0.539

At higher pressures

20°C (23)

p, atm	59	72	83
$10^3\eta$	0.697	0.771	0.823

25.1°C (36)

p, atm	70	75	85	95	105
$10^3\eta$	0.628	0.665	0.703	0.741	0.800

30°C (23)

p, atm	72	73	74	76	80
$10^3\eta$	0.458	0.478	0.495	0.529	0.565

30°C (23)

p, atm	82	90	96	104	110.5
$10^3\eta$	0.592	0.643	0.693	0.733	0.770

At the critical point, $10^3\eta$ is 0.321 (23).

ORGANIC LIQUIDS

$CHCl_3$, Chloroform

$a = 93.3 \pm 0.5$, $b = 163$, $n = 1.865$, if t lies between −15 and 60° (32); *cf.* (13, 21, 40)

t, °C	−10	0	+10	20	30	40	50	60
$10^3\eta$	7.86	6.99	6.25	5.63	5.10	4.64	4.24	3.89

P	500	1 000	2 000	4 000	(3)
k_{30}	5.77	6.25	7.16	8.92	
k_{75}	6.81	7.22	7.36	7.96	

Chloroform.—(*Continued*)

P	6 000	8 000	10 000	(3)
k_{30}	11.08			
k_{75}	9.68	12.98	18.19	

CH_3OH, Methyl Alcohol

$a = 21\,000 \pm 100$, $b = 175.5$, $n = 2.858$, if t lies between 0 and 66°C (32); *cf.* (2, 10)

t, °C	0	10	20	30	40	50	60
$10^3\eta$	8.08	6.90	5.93	5.15	4.49	3.95	3.49

P	500	1 000	2 000	4 000	(3)
k_{30}	4.85	4.69	4.66	4.89	
k_{75}	4.79	4.59	4.40	4.37	

P	6 000	8 000	10 000	12 000	(3)
k_{30}	5.21	5.78	6.48	7.46	
k_{75}	4.45	4.72	5.11	5.58	

C_2H_5OH, Ethyl Alcohol

$a = (8.20 \pm 0.04) \times 10^7$, $b = 200$, $n = 4.2$, if t lies between 0 and 75°C (32); *cf.* (2, 10, 11, 33, 34, 35)

t, °C	0	10	20	30	40	50	60	70
$10^3\eta$	17.90	17.52	17.16	16.81	16.47	16.13	15.81	15.49

P	k_0	$k_{15.1}$	k_{30}	$k_{53.5}$	k_{75}	Lit.
400	8.2	8.0				(9)
500			5.59		6.07	(3)
1 000	7.9	8.2	6.4	4.4		(9)
1 000			5.85		6.44	(3)
2 000	9.6	8.6	6.9	5.0		(9)
2 000			6.54		7.22	(3)
2 500	10.2	9.0	7.3	5.5		(9)
4 000			7.85		8.25	(3)
6 000			9.57		9.25	(3)
8 000			11.92		10.60	(3)
10 000			15.25		12.27	(3)
12 000			19.62		14.40	(3)

$(C_2H_5)_2O$, Ethyl Ether

Excepting from 0 to +30°C, only non-overlapping series of data are available for variation of η with t; different series do not agree satisfactorily; for each, $\eta = c(10)^{-3}/[1 + dt(10)^{-3} + et^2(10)^{-6}]$ with average deviation of δ. Actual uncertainty exceeds δ and, except between 0 and +30°C, may amount to several %.

Range	c	d	e	δ	Lit.
0 to +30°C	2.842	10.40	26.2	0.1%	(32); *cf.* (10, 18, 27, 40)
0 to +50	2.876*	10.40	26.2	0.2	(15, 16)
+50 to +100	2.520*	4.395	70.2	0.1	(15, 16)
0 to − 32	2.898	10.54	26.1	0.1	(41); *cf.* (20)
−40 to −110	2.793	10.87	25.2	0.5	(41); *cf.* (20)

t, °C	−110	−100	−90	−80	−60	−40	−30	−20
$10^3\eta$	25.6	16.9	12.4	9.58	6.37	4.61	4.10	3.62
t, °C	−10	0	+20	30	40	60	80	100
$10^3\eta$	3.23	2.842	2.332	2.128	1.97	1.66	1.40	1.18

* At pressure of saturated vapor.

P	k_0 (9)	k_{20} (9)	k_{30} (3)	k_{34} (9)	k_{75} (3)
500	9.6	9.6	10.92	8.7	8.02
1 000	10.4	10.0	11.09	9.2	8.66
2 000	12.4	11.3	11.32	10.5	9.62
3 000	15.1	14.1	12.0	13.2	10.0
4 000			12.98		10.71
6 000			16.69		12.45
8 000			21.55		14.78
10 000			28.45		17.92
12 000			38.15		21.75

C_6H_6, Benzene

$a = 14.42 \pm 0.03$, $b = 90$, $n = 1.64$; if t lies between 0 and 75°C (27, 32, 40); *cf.* (10)

t, °C.	0	10	20	30	40	50	60	70
$10^3\eta$	9.00	7.57	6.47	5.61	4.92	4.36	3.893	3.502

For the liquid under the pressure of its saturated vapor the viscosity ($\eta_{p,t}$) may be calculated by means of the equation $\eta_{p,t} = \eta_{1,t}\ [1 - 0.0123(p - 1)]$, if t lies between 0 and 190°C, where $\eta_{1,t}$ is value of η at $t°$ and 1 atm. as computed by the preceding formula ($\eta_{1,t} = 14.42/(90 + t)^{1.64}$), and p is the pressure (in atm.) of the saturated vapor. Observations between 0 and 100°C lie on the average 1.3% below the computed values, from 100 to 190° observed and computed agree to within 0.1% (15, 16).

P	500	1000	2000	3000	Lit.
k_{30}	9.80	12.23			(3)
k_{75}	9.80	10.70	12.45	14.70	

LITERATURE

(For a key to the periodicals see end of volume)

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(20) Kugelmass, *70*, **41**: 751, 755; 22. (21) Linebarger, *12*, **2**: 331; 96. (22) Lyle and Hosking, *3*, **3**: 487; 02. (23) Phillips, *5*, **87**: 48; 12. (24) Poiseuille, *Paris, Mém. Savants Étranq.*, **9**: 433; 46. *34*, **11**: 961, 1041; 40. **12**: 112; 41. **15**: 1167; 42. (25) Poiseuille, *6*, **21**: 76; 47. (26) Pound, *4*, **99**: 698; 11. (27) Přibram and Handl, *75*, **80 II**: 17; 79. (28) Röntgen, *8*, **23**: 510; 84. (29) Sachs, *Diss.*, Freiburg, 1883.
(30) Slotte, *8*, **20**: 257; 83. (31) Sprung, *8*, **159**: 1; 76. (32) Thorpe and Rodger, *62*, **185**: 397; 94. (33) Tower, *1*, **38**: 833; 16. (34) Traube, *25*, **19**: 871; 86. (35) Völlmer, *8*, **52**: 328; 94. (36) Warburg and von Babo, *8*, **17**: 390; 82. (37) Warburg and Sachs, *8*, **22**: 518; 84. (38) Washburn and Williams, *1*, **35**: 737; 13. (39) White and Twining, *11*, **50**: 380; 13.
(40) Wijkander, *427*, **3**: 8; 79. (41) Archibald and Ure, *4*, **1927**: 610.

VISCOSITY OF AQUEOUS SOLUTIONS OF STRONG ELECTROLYTES

Stuart J. Bates and Warren P. Baxter

In the following tables, the concentration F, is given in formula weights per 1000 g of water, and η^* is the viscosity referred to that of water at the same temperature as unity, except as otherwise noted. Temperature in °C is indicated by the subscript.

Few of the investigators have determined and applied any correction for failure of their viscometers to obey Poiseuille's law exactly. Where feasible, corrections of this nature have therefore been applied.

In general, the last figure given is to be regarded as not being in error by more than 5 units. Where it is given in smaller type, the probable error is somewhat greater, and the last figure may or may not be significant. In cases where it has been possible to estimate the probable error with considerable certainty, this is given. Thus for HCl at 25° and 1F the relative viscosity is 1.060 ± 0.003. This indicates that the probable error for all solutions up to a concentration of 1F is about 0.3%.

For some electrolytes, additional data, chiefly at higher or lower temperatures or at higher concentrations than those covered by the tables, may be found by consulting the literature.

Should it be desired to interpolate the viscosity data to other units of concentration, for example to (volume) normal, this may usually be readily done algebraically by noting that, in general, for small changes of concentration, the expression $\frac{\eta/\eta_0 - 1}{F}$ changes but slowly with the concentration.

* All interconversions between η and η/η_w have been based upon the values for water given on page 10.

AQUEOUS SOLUTIONS CONTAINING A SINGLE STRONG ELECTROLYTE

$\mathfrak{B}$-Table; Standard Arrangement (*v.* Vol. III, p. viii)

HCl (27, 45, 66, 69, 91); *cf.* (103)

F	η_0 (91)	F	η_{25}	F	η_{25}
1	1.020*	0.1	1.007†	6	1.355
2	1.040	0.25	1.017†	7	1.418
3	1.058	0.5	1.032†	8	1.485
	η_{15} (91)	1	1.060†	9	1.56
		2	1.116	11	1.71
1	1.041*	3	1.175	13	1.86
2	1.083	4	1.233	16	2.12
3	1.125	5	1.294	* ±0.005.	† ±0.003.

$HClO_3$

F	η_{15} (79)
0.25	1.004
0.5	1.010
1.0	1.030
F	η_{25} (66)
0.1	1.005*
0.25	1.013*
0.5	1.025*
1.0	1.051*

* ±0.003.

$HClO_4$ (100)

M %	η_{20}	η_{50}
5	1.05	1.13
10	1.29	1.42
15	1.74	1.89
20	2.51	2.72
25	3.41	3.64
30	4.44	4.77
35	5.75	6.04
40		6.77

$HClO_4$.—(*Cont'd*)

M %	η_{20}	η_{50}
45		6.82
50		6.10
65		3.66
75		2.45
80	1.77	2.06
100	0.76	1.03

F	η_{25} (66)
0.25	1.000
0.5	1.003
1.0	1.011

HBr

F	η_0 (91)
1	0.987*
2	0.974
3	0.964
F	η_{15} (91)
1	1.014*
2	1.029
3	1.045

HBr.—(*Cont'd*)

F	η_{25} (15, 66, 91)
0.25	1.008†
0.5	1.016†
1.0	1.031†
2	1.058
3	1.081

* ±0.005. † ±0.002.

$HBrO_3$ (80)

F	η_{15}
0.25	1.016
0.5	1.034
0.75	1.053

HI (88)

F	η_{25}
0.1	0.996
0.2	0.9954

H_2SO_4

F	Values of η						
	20° (29)	25° (29, 95)	40° (29)	60° (29)	80° (29)	Wt. %	80° (29)
0.1		1.017				10	1.24
0.25		1.043				20	1.55
0.5	1.090	1.091	1.096	1.103	1.120	30	2.05
1.0	1.184	1.185	1.188	1.197	1.211		
2.0	1.405	1.406	1.409	1.41	1.41		
4.0	1.89	1.89	1.89	1.89	1.90		

Wt. %	Values of η						
	0° (67)	10° (3)	20° (29)	25° (3, 18, 19)	40° (3, 29)	60° (29)	75° (67)
10	1.2	1.2	1.211	1.212	1.215	1.223	1.23
20	1.45	1.5	1.535	1.535	1.537	1.54	1.55
30	1.9	1.97	2.02	2.02	2.02	2.02	2.04
40	2.6	2.60		2.68	2.72		2.8

H_2SO_4.—(*Continued*)

Wt. %	Values of η						
	0° (67)	10° (3)	20° (29)	25° (3, 18, 19)	40° (3, 29)	60° (29)	75° (67)
50	3.6	3.74		3.83	3.80		4.2
60	6.0	5.8		5.9	5.8		6
70	11	10		10.0	9.3		8
75	17	16		14.3	12.8		10
80				20.3			
86				24.7			
90	26			23.5			14
95	25			21.9			14
98	29	27		23.2	20		15

HNO_3

F	Values of η			
	4° (9)	11° (9)	18° (9)	25° (9, 66)
0.1	0.9956	0.9990	1.0011	1.0035
0.25	0.9927	0.9987	1.0030	1.0074
0.5	0.9903	1.0007	1.0072	1.0133
1	0.9886	1.0100	1.0197	1.0295

Wt. %	10° (3)	20° (3, 25)	40° (3)	−15°† (49)
10	1.005	1.035	1.075	
25	1.14	1.20	1.28	0.0272
40	1.46	1.56	1.63	0.0353
50	1.76	1.82	1.91	0.0445
60	2.00	2.03	2.07	0.0562
70	1.99	2.03	2.06	0.0581
80	1.80	1.86	1.94	0.0427
90	1.27	1.35	1.48	
100	0.79	0.89	1.04	

† In poises.

NH_4OH

F	η
25° (4, 5, 43)	
0.25	1.005*
0.5	1.010*
1	1.019*
2	1.038*
3	1.055*
4	1.071
5	1.086
6	1.100
7	1.114
8	1.127
9	1.139
10	1.151
11	1.162
12	1.173
13	1.182

* ±0.003.

NH_4NO_3

F	Values of η				F	η	F	η
	10° (84)	20° (84)	40° (84)	50° (84)	25° (23, 43)			
1	0.943	0.965	0.996	1.012	0.25	0.993	4	0.981
2	0.912	0.954	1.005	1.03	0.5	0.986	5	1.009
5	0.920	0.988	1.09	1.13	1.0	0.973	6	1.042
7.5	0.985	1.060	1.19	1.25	2	0.956		
12	1.185	1.295	1.455	1.535	3	0.960		

NH_4Cl

F	Values of η					
	0° (84)	10° (84)	18°* (2, 12, 72)	25°† (5, 23, 32, 43)	40° (84)	60° (84)
0.25			0.993	0.997		
0.5			0.987	0.994		
1	0.931	0.965	0.978	0.991	1.014	1.033
2	0.891	0.940	0.965	0.988	1.028	1.065
3	0.863	0.924	0.961	0.993	1.045	1.095
4	0.846	0.917	0.963	1.002	1.065	1.13
5			0.970	1.017		
6	0.829	0.924	0.983	1.034	1.12	1.20

* ±0.003. † ±0.005.

NH_4Br

F	Values of η					
	0° (84)	10° (84)	20° (84)	25° (23)	40° (84)	60° (84)
2	0.830	0.890	0.932	0.945	0.987	1.035
3.5	0.784	0.856	0.917	0.934	0.997	1.07
6	0.772	0.854	0.930	0.957	1.045	1.145

At 25°, F = 0.25; 0.993. F = 0.5; 0.985. F = 1; 0.970. F = 5; 0.945 (23).

NH_4I

F	Values of η					
	10° (23)	15° (23)	20° (23)	25° (23)	30° (65)	45° (65)
0.25				0.981	0.986	0.991
0.5				0.963	0.971	0.982
1	0.892	0.901	0.917	0.932	0.947*	0.970*
2	0.809	0.840	0.869	0.892		
3.5	0.760	0.808	0.838	0.878		
5	0.764	0.810	0.844	0.894	0.911	
6.5	0.794	0.840	0.878	0.926		
9					1.027	

*±0.003.

$(NH_4)_2SO_4$

F	Values of η						
	0° (84)	10° (84)	20° (29, 84)	25° (43)	40° (29, 84)	60° (29, 84)	80° (29)
0.25				1.053			
0.5			1.092	1.100	1.112	1.134	1.162
1.0	1.13	1.18	1.198	1.209	1.236	1.269	1.30
2.0			1.452		1.52	1.57	1.61
2.5	1.46	1.55		1.61	1.67	1.74	
4.5			2.32		2.43	2.50	2.56

H_3PO_4

F	η_{18} (57)	η_{25} (66)
0.25	1.064	1.062
0.5	1.140	1.130
1	1.294	1.273
2	1.650	

H_3AsO_4

F	η_{25} (66)
0.1	1.023
0.25	1.060
0.5	1.126
1	1.257

CH_3NH_3OH

F	η_{25} (43)
0.1	1.013
0.25	1.034
0.5	1.071
1	1.146

$(CH_3)_2NH_2OH$

F	η_{25} (43)
0.1	1.025
0.25	1.064
0.5	1.134
1	1.279

$NH_4C_2H_3O_2$

F	η_{15} (81)
0.25	1.058
0.5	1.117
1	1.238

$(CH_3)_3NHOH$ (43)

F	η_{25}
0.1	1.053
0.25	1.139
0.5	1.282
1	1.599

$(CH_3)_4NOH$ (43)

F	
0.1	1.028
0.25	1.070
0.5	1.140
1	1.286

CH_3NH_3Cl (43)

F	η_{25}
0.1	1.005
0.25	1.014
0.5	1.028
1	1.057

$(CH_3)_2NH_2Cl$ (43)

0.1	1.010
0.25	1.025
0.5	1.051
1	1.099

$C_2H_5NH_3Cl$ (43)

0.1	1.015
0.25	1.038
0.5	1.076
1	1.154

$(CH_3)_3NHCl$ (43)

0.1	1.039
0.25	1.098
0.5	1.201
1	1.439

$(CH_3)_4NCl$ (43)

0.1	1.014
0.25	1.037
0.5	1.073
1	1.146

$(C_2H_5)_2NH_2Cl$ (43)

0.1	1.029
0.25	1.073
0.5	1 146
1	1.294

$C_6H_5NH_3Cl$ (74)

0.1	1.040
0.25	1.082
0.5	1.150
1	1.292
2	1.568
3	1.855
4	2.183
5	2.560
6	2.990
7	3.445

$(C_2H_5)_3NHCl$ (43)

F	η_{25}
0.1	1.038
0.25	1.098
0.5	1.199
1	1.414

$(C_2H_5)_4NCl$ (90)

F	η_{25}	η_{35}
0.25	1.089	1.089
0.5	1.190	1.188
1	1.436	1.432

$(C_3H_7)_4NCl$ (90)

0.25	1.216	1.190
0.5	1.494	1.436
0.75	1.786	1.750

$(C_2H_5)_4NBr$ (90)

0.25	1.087	1.081
0.5	1.186	1.174
1	1.406	1.385

$(CH_3)_4NI$ (90)

0.1	1.005	1.004
0.25	1.012	1.012

$(C_3H_7)_4NI$ (90)

0.25	1.199	1.182
0.5	1.458	1.426

$Pb(NO_3)_2$

F	η_{18} (28)
0.1	1.0165
0.25	1.0435
0.5	1.0971

F	η_{25} (32, 95)
0.1	1.019
0.25	1.049
0.5	1.105
1.0	1.255
1.5	1.447

$Pb(C_2H_3O_2)_2$ (47)

F	η_{15}	η_{20}
0.25	1.140	1.139
1	1.647	1.603
F	η_{25}	η_{30}
0.25	1.138	1.137
1	1.560	1.559

TlOH (102)
$TlNO_3$ (95)

F	η_{25}
0.1	0.994
0.25	0.987

$ZnCl_2$

F	η_{18} (2)
0.5	1.187
F	η_{25} (4, 95)
0.1	1.039
0.25	1.096
0.5	1.187

$ZnSO_4$

F	η_{18} (2)
0.5	1.361
F	η_{25} (4, 32, 95)
0.1	1.063
0.25	1.167
0.5	1.366
1	1.895
2	3.78

$Zn(NO_3)_2$ (95)

F	η_{25}
0.1	1.030
0.25	1.079
0.5	1.164

$CdCl_2$ (95)

0.1	1.023
0.25	1.063
0.5	1.132

$CdSO_4$ (95)

0.1	1.060
0.25	1.158
0.5	1.344

$Cd(NO_3)_2$ (95)

0.1	1.028
0.25	1.074
0.5	1.161

$HgCl_2$ (33, 65, 95)

0.1	1.012
0.25	1.032

$Hg(CN)_2$

F	η_{15} (65)
0.1	1.014
0.25	1.036
F	η_{25} (33, 65)
0.1	1.013
0.25	1.034
0.4	1.055
F	η_{45} (65)
0.1	1.012
0.25	1.031

$CuCl_2$

F	η_{18} (72)	η_{25} (32, 95)
0.1	1.040	1.040
0.25	1.100	1.102
0.5	1.201	1.208
1	1.425	1.435
2	1.943	1.942
3		2.564

$CuSO_4$

F	η_{18} (2)	η_{25} (4, 32, 95)
0.1	1.063	1.061
0.25	1.169	1.161
0.5	1.369	1.357
0.75	1.607	1.598
1		1.875

$Cu(NO_3)_2$

F	η_{18} (2)	η_{25} (4, 95)
0.1	1.034	1.030
0.25	1.089	1.080
0.5	1.188	1.174
1	1.435	
2	2.04	2.01
4.5	5.45	5.25
F	η_{35} (94)	η_{45} (94)
2	1.98	1.95
4.5	4.95	4.63

$Cu(CHO_2)_2$ (73)

F	η_{18}
0.05	1.032
0.1	1.058
0.2	1.108
0.3	1.157

$Cu(C_2H_3O_2)_2$ (73)

0.05	1.041
0.1	1.081
0.2	1.156

$Cu(C_3H_5O_2)_2$ (73)

0.05	1.058
0.1	1.105
0.2	1.200

$AgNO_3$ (4, 70, 95)

F	η_{25}
0.25	1.008
0.5	1.020
1	1.055
3	1.265
6	1.65
12	2.71

$AgTl(NO_3)_2$
0 to 100 % of salt at 100° (64)

$MnCl_2$ (32, 95)

F	η_{25}
0.1	1.038
0.25	1.098
0.5	1.207
1	1.44
2	2.04
3	2.89

$MnSO_4$ (32, 95)

0.1	1.064
0.25	1.169
0.5	1.368
1	1.90
2	3.86
3	7.99

$Mn(NO_3)_2$ (32, 95)

F	η_{25}
0.1	1.033
0.25	1.085
0.5	1.176
1	1.370
2	1.84
3	2.49

$FeCl_3$

F	η_0 (56)	η_{18} (56)
0.05	1.035	1.036
0.1	1.070	1.073
0.25	1.18	1.18
0.5	1.39	1.38
0.75	1.64	1.62
1.0	1.93	1.88
1.5	2.07	2.53
2.0	3.64	3.30
3.0	6.9	5.7
4.7	19.0	12.7
F	η_{25} (43, 56)	η_{35} (56)
0.05	1.036	1.034
0.1	1.072	1.067
0.25	1.18	1.17
0.5	1.37	1.35
0.75	1.60	1.57
1.0	1.85	1.80
1.5	2.45	2.34
2.0	3.18	3.00
3.0	5.2	3.9
4.7	11.3	9.8

$CoCl_2$ (54, 95, 99)

F	η_{25}
0.1	1.038
0.25	1.098
0.5	1.202
1	1.432
F	η_{75} (99)
1	1.408

$CoSO_4$ (95)

0.1	1.060
0.25	1.160
0.5	1.353

$Co(NO_3)_2$ (95)

0.1	1.028
0.25	1.074
0.5	1.162

$Co(CNS)_2$ (99)

F	η_{25}
0.5	1.195
F	η_{75}
0.5	1.185

$NiCl_2$ (95)

F	η_{25}
0.1	1.036
0.25	1.094
0.5	1.204

$NiSO_4$ (95)

0.1	1.059
0.25	1.161
0.5	1.361

$Ni(NO_3)_2$ (95)

0.1	1.032
0.25	1.083
0.5	1.177

CrO_3 (104)
H_2CrO_4 (83)

F	η_{10}	η_{20}
2	1.12	1.14
4	1.315	1.365
7	1.715	1.765
12	2.675	2.715
F	η_{30}	η_{40}
2	1.16	1.17
4	1.395	1.42

H_2CrO_4.—(*Cont'd*)

F	η_{30}	η_{40}
7	1.805	1.835
12	2.74	2.755

F	η_{15} (78)
0.25	1.016
0.5	1.032
1	1.064
2	1.129

$CrCl_3$ (61)

F	η_{18}	η_{25}
Green solution		
0.25	1.078	1.109
0.5	1.168	1.22
1	1.39	1.45
Violet solution		
0.25	1.160	1.150
0.5	1.340	1.315
1	1.75	1.78

$Cr_2(SO_4)_3$ (26)

F	η_{10}	η_{20}	η_{25}	η_{40}	η_{60}
Violet solution					
0.1	1.222	1.190	1.182	1.165	1.120
0.2	1.510	1.485	1.485	1.430	1.33
0.3	1.950	1.935	1.920	1.845	1.685
Green solution					
0.1	1.145	1.125	1.117	1.110	1.100
0.2	1.360	1.325	1.310	1.290	1.250
0.3	1.71	1.65	1.65	1.605	1.50

$(NH_4)_2Cr_2O_7$ (82)

F	η_{10}	η_{20}
0.25	0.990	1.000
0.5	0.990	1.011
1	1.006	1.046
F	η_{30}	η_{40}
0.25	1.013	1.027
0.5	1.032	1.055
1	1.081	1.111

$(NH_4)_2CrO_4$ (82)

F	η_{10}	η_{20}
0.5	1.052	1.069
1	1.112	1.143
2.5	1.37	1.422
F	η_{30}	η_{40}
0.5	1.079	1.095
1	1.164	1.19
2.5	1.47	1.515

$Al_2(SO_4)_3$ (95)

F	η_{25}
0.05	1.100
0.1	1.219
0.15	1.355

$BeCl_2$ (21)

0.15	1.065
0.25	1.110

$BeSO_4$ (95)

0.1	1.060
0.25	1.161
0.5	1.356

$MgCl_2$

F	η_{18} (28)	η_{25} (32, 95)
0.05	1.022	1.016
0.1	1.042	1.034
0.25	1.102	1.093
0.5	1.209	1.200
1		1.468
2		2.233
3		3.361

$MgSO_4$

F	η_{18} (2, 28, 84)	η_{25} (32, 95)
0.05	1.033	1.030
0.1	1.067	1.061
0.25	1.173	1.164
0.5	1.379	1.366
1	1.95	1.93
2	3.95	3.80

F	η_{40} (84)
1	1.89
2	3.55

$Mg(NO_3)_2$

F	η_{25} (32)
0.5	1.165
1	1.374
2	1.95
3	2.84

$Mg(C_2H_3O_2)_2$ (68)

$MgCrO_4$ (82)

F	η 10°	20°	40°
1	1.52	1.51	1.49
2	2.28	2.23	2.16

$CaCl_2$

F	η_{10} (84)	η_{40} (84)
2	1.72	1.82
4	3.48	3.72
6	9.4	8.2
F	η_{18} (28, 75, 84)	η_{25} (52, 84, 95)
0.1	1.030	1.030
0.25	1.075	1.076
0.5	1.148	1.155
1	1.308	1.33
2	1.74	1.78
4	3.54	3.60
6	9.00	8.5

$Ca(NO_3)_2$ (58, 95)

F	η_{25}
0.1	1.020
0.25	1.054
0.5	1.120
1	1.290
2	1.750
3	2.450

$Ca(C_2H_3O_2)_2$ (81)

F	η_{15}
0.25	1.212
0.5	1.465
1	2.135

$CaCrO_4$ (28)

F	η_{18}
0.05	1.026
0.1	1.051
0.25	1.129
0.5	1.272

$SrCl_2$

F	η_{18} (72)	η_{25} (32, 95)
0.1	1.027	1.027
0.25	1.067	1.069
0.5	1.139	1.146
1	1.300	1.33
2	1.77	1.81
3	2.50	2.56
F	η_{40} (84)	
0.5	1.16	
1	1.35	
2	1.85	
3	2.63	

$Sr(NO_3)_2$ (95)

F	η_{25}
0.1	1.019
0.25	1.050
0.5	1.112

$Sr(C_2H_3O_2)_2$ (81)

F	η_{15}
0.25	1.212
0.5	1.465
1	2.135

$Ba(OH)_2$ (102)

$BaCl_2$

F	η_{10} (54, 84)	η_{50} (54, 84)
0.25	1.045	1.070
0.5	1.095	1.14
1	1.22	1.31
F	η_{18} (2, 12, 72)	η_{25} (32, 95)
0.1	1.024	1.024
0.25	1.060	1.061
0.5	1.120	1.126
1	1.259	1.285

$BaBr_2$ (17)

F	η_{18}
0.1	1.018

$Ba(NO_3)_2$ (95)

F	η_{25}
0.1	1.017
0.25	1.043

$Ba(C_2H_3O_2)_2$ (81)

F	η_{15}
0.25	1.202
0.5	1.426
1	2.019

$Ba(CNS)_2$ (99)

F	η_{25}	η_{75}
0.5	1.106	1.131

LiOH (10); *cf.* (102)

F	η_0	η_{25}
0.5	1.13	1.12
1	1.24	1.23
2	1.67	1.61
4	3.40	2.88
F	η_{50}	η_{75}
0.5	1.11	1.10
1	1.22	1.21
2	1.56	1.51
4	2.58	2.30

LiCl

F	η_{18} (2, 8, 27, 28, 36)	η_{25} (27, 52, 62, 70, 95)
0.1	1.0160	1.014
0.25	1.0385	1.035
0.5	1.0747	1.069
1	1.1476	1.142
2	1.298	1.302
3	1.473	1.479
4	1.669	1.673
5	1.891	1.895
6	2.145	2.155
7	2.445	2.455
8	2.801	2.81
9	3.235	3.235
10	3.765	3.73
11	4.405	4.33
12	5.14	5.06
13	6.03	5.94
14	7.14	6.99
15	8.47	8.23
16	9.99	9.60
17	11.80	11.12
20		18.9

LiCl.—(*Cont'd*)

F	η_0 (36, 97)	η_{10} (36, 84)
0.1	1.012*	
0.25	1.033*	
0.5	1.069*	1.071
1	1.129*	1.141
3	1.454	1.465
6	2.09	2.125
9	3.24	3.23
14		7.34
F	η_{40} (36, 84)	η_{60} (36)
0.5	1.067	1.066
1	1.143	1.143
3	1.495	1.515
6	2.185	2.215
9	3.26	3.28
14	6.69	6.40
F	η_{80} (36)	η_{100} (36)
0.5	1.068	1.066
1	1.140	1.140
3	1.53	1.53
6	2.24	2.26
9	3.28	3.26
14	6.16	5.92

* ±0.002.

$LiClO_3$ (70)

F	η_{25}
1	1.141
3	1.456
7	2.44
17	9.19
35	61

LiBr (41, 71)

0.1	1.015

$LiBrO_3$ (89)

F	η_{20}
0.1	1.017
0.25	1.044
0.5	1.090
0.8	1.146

$LiIO_3$ (28)

F	η_{18}
0.05	1.0158
0.2	1.0622
1	1.3815
3	3.020

Li_2SO_4

F	η_{18}* (2, 28)
0.05	1.0294
0.1	1.0568
0.25	1.1420
0.5	1.300
F	η_{25} (5, 95)	η_{40} (93)
0.1	1.053†	1.049‡
0.25	1.136†	1.128‡
0.5	1.287†	1.27‡
1	1.665	1.63

* ±0.001. † ±0.005. ‡ ±0.01.

$LiNO_3$

F	η_0 (1)
0.05	1.0038
0.1	1.0070
0.25	1.0166
0.5	1.0323
1	1.0687
2	1.157
3	1.274

$LiNO_3$.—(*Cont'd*)

F	η_{18} (1, 28)	η_{25} (1)
0.05	1.0060	1.0060
0.1	1.0109	1.0116
0.25	1.0259	1.0277
0.5	1.0503	1.0534
1	1.0996	1.1063
2	1.2110	1.2230
3	1.341	1.358
4	1.492	1.514
5	1.670	1.694
6	1.874	1.898
9		2.730

$LiC_2H_3O_2$

F	η_{15} (81)
0.25	1.115
0.5	1.234
1	1.475

NaOH

See also (102)

F	η_{18} (57)	η_{25} (43)
0.1	1.020	1.023
0.25	1.052	1.055
0.5	1.108	1.110
1	1.234	1.236
2	1.59	
4	2.78	
8	7.04	

NaCl and NaI: *v. next column*

$NaIO_3$ (28)

F	η_{18}
0.2	1.0493

$NaHSO_4$ (57)

F	η_{18}
0.25	1.056
0.5	1.114
1	1.245
2	1.550
5	2.874

Na_2SO_4

F	η_{10} (84, 92)	η_{25} (2, 84, 92, 95)
0.1	1.036	1.040
0.25	1.096	1.106
0.5	1.217	1.227
0.75	1.372	1.374
1	1.56	
F	η_{40} (84, 92)	
0.1	1.044	
0.25	1.109	
0.5	1.226	
0.75	1.365	
1	1.54	

NaN_3 (11)

F	η_0	η_{25}
1.5	1.089	1.126
3	1.294	1.343
5	1.82	1.82
6		2.10

NaCl

18° (2, 7, 12, 22, 28, 53); 25° (32, 35, 66, 69, 76); 0°, 80°, 100° (35, 53); 10°, 40°, 60° (35, 53, 84)

F	Values of η							
	0°	10°	18°	25°	40°	60°	80°	100°
0.1	1.004*	1.006*	1.0085†	1.009‡	1.010*	1.012*	1.013*	1.013*
0.25	1.009*	1.016*	1.0205†	1.022‡	1.026*	1.030*	1.031*	1.032*
0.5	1.020*	1.032*	1.0405†	1.046‡	1.053*	1.060*	1.062*	1.065*
1	1.047*	1.071*	1.0840†	1.094‡	1.108*	1.121*	1.127*	1.131*
2	1.147	1.173	1.192	1.205	1.229	1.249	1.26	1.26
3	1.282	1.312	1.329	1.341	1.365	1.39	1.40	1.405
4	1.450	1.481	1.498	1.509	1.524	1.54	1.55	1.555
5		1.692	1.700	1.706	1.713	1.72		

* ±0.005. † ±0.001. ‡ ±0.002.

F	$NaClO_3$ Values of η			$NaClO_4$	$NaBrO_3$	
	15° (79, 84)	25° (66, 84)	40° (84)	25° (66)	15° (80)	20° (89)
0.25	1.012	1.021		1.008	1.022	1.028
0.5	1.028	1.041		1.018	1.047	1.057
1	1.067	1.086	1.10	1.044	1.101	1.117
2.5	1.24	1.265	1.285			
4.5	1.61	1.625	1.64			

NaBr (84) except at 25° (66)

F	Values of η						
	25°	F	10°	20°	25°	40°	60°
0.1	1.005	1	1.029	1.054	1.062*	1.08	1.10
0.25	1.014	2	1.108	1.141	1.154	1.18	1.215
0.5	1.029	3.5	1.29	1.328	1.338	1.365	1.405

* ±0.003.

NaI (84)

F	Values of η					
	10°	20°	30°	40°	50°	60°
0.5	1.000	1.011	1.017	1.024	1.028	1.033
1.5	1.012	1.042	1.060	1.079	1.092	1.106
4	1.193	1.227	1.253	1.284	1.312	1.334
8	2.035	2.03	2.03	2.045	2.06	2.07

NaN_3.—(*Cont'd*)

F	η_{35}	η_{50}
1.5	1.135	1.148
3	1.358	1.385
5	1.81	1.80
6	2.07	2.03

$NaNO_3$

F	η_{10} (84)	η_{40} (84)
1	1.041	1.08
2	1.125	1.18
3	1.24	1.30
5	1.58	1.62
F	η_{18} (2, 22, 28, 59, 84)	η_{25} (66)
0.1	1.0043*	1.005†
0.25	1.0101*	1.012†
0.5	1.0216*	1.025†
1	1.0521*	1.062†
2	1.15	
3	1.27	
5	1.60	

* ±0.0005. † ±0.003.

NaH_2PO_4 (66)

F	η_{25}
0.1	1.040
0.25	1.102
0.5	1.208
1	1.464

NaH_2AsO_4 (66)

0.1	1.040
0.25	1.104
0.5	1.217
1	1.484

Na_2CO_3

See also (102)

F	η_{18} (57, 83)	η_{25} (43, 83)
0.1	1.048	1.048
0.25	1.126	1.130
0.5	1.274	1.285
1	1.660	
2	3.040	2.93

$Na_2C_2O_4$ (50)

F	η_{25}
0.05	1.022
0.1	1.046

$Na_2C_4O_4$ (50)

Acetylenedicarboxylate

F	η_{25}
0.1	1.127

$NaHCO_2$ (66, 81)

Formate

0.1	1.018
0.25	1.045
0.5	1.094
1	1.202

$NaHCO_3$ (57)

F	η_{18}
0.25	1.057
0.5	1.118
1	1.253

$NaC_2H_3O_2$

F	η_{15} (81)	η_{25} (66)
0.1		1.035
0.25	1.091	1.088
0.5	1.184	1.176
1	1.389	1.373

$NaC_2H_3O_3$ (50)
Glycolate

F	η_{25}
0.1	1.031
0.25	1.078
0.5	1.155
1	1.325

$NaC_3H_5O_2$ (66, 81)
Propionate

0.1	1.043
0.25	1.110
0.5	1.228
1	1.504

$NaC_3H_5O_3$ (66)
Lactate

0.1	1.040
0.25	1.103
0.5	1.216
1	1.464

$NaC_4H_5O_6$ (57)
Acid tartrate

F	η_{18}
0.25	1.095
0.5	1.195

$NaC_4H_7O_2$ (66)
Butyrate

F	η_{25}
0.1	1.052
0.25	1.133
0.5	1.280
1	1.620

$NaC_4H_7O_2$ (66)
Isobutyrate

0.1	1.056
0.25	1.140
0.5	1.287
1	1.627

$NaC_5H_9O_2$ (66)
Isovalerate

0.1	1.060
0.25	1.153
0.5	1.316

$NaC_6H_{11}O_2$ (66)
Isocaproate

0.1	1.063
0.25	1.166
0.5	1.355

$NaC_7H_5O_2$ (66)
Benzoate

0.1	1.050
0.25	1.127
0.5	1.264
1	1.581

$NaC_7H_5O_3$ (50)
m-Hydroxybenzoate

0.1	1.030
0.25	1.086
0.5	1.220
1	1.608

$NaC_7H_5O_3$ (50)
p-Hydroxybenzoate

0.1	1.050
0.25	1.129
0.5	1.277
1	1.653

$NaC_7H_5O_3$ (66)
Salicylate

F	η_{25}
0.1	1.041
0.25	1.102
0.5	1.210
1	1.468

$NaC_8H_7O_2$ (50)
Phenylacetate

0.1	1.056
0.25	1.145
0.5	1.304
1	1.668

$NaC_8H_7O_2$ (50)
o-Toluate

0.1	1.061
0.25	1.157

m-Toluate

0.1	1.038
0.25	1.103
0.5	1.248
1	1.606

p-Toluate

0.1	1.056
0.25	1.146
0.5	1.308
1	1.695

$NaC_8H_7O_3$ (50)
Phenoxyacetate

0.1	1.056
0.25	1.143
0.5	1.294
1	1.654

$NaC_8H_7O_3$ (50)
Anisate

0.1	1.055
0.25	1.142
0.5	1.302

$NaC_8H_7O_3$ (50)
Phenylglycolate

0.1	1.055
0.25	1.143
0.5	1.295
1	1.658

$NaC_9H_7O_2$ (50)
Cinnamate

0.1	1.054
0.25	1.154
0.5	1.334

$NaC_9H_9O_2$ (50)
Hydrocinnamate

0.1	1.065
0.25	1.165
0.5	1.337
1	1.773

$Na_2C_3H_2O_4$ (50)
Malonate

0.1	1.034
0.25	1.107
0.5	1.252

$Na_2C_4H_2O_4$ (50)
Maleate

0.1	1.035
0.25	1.109
0.5	1.270

$Na_2C_4H_2O_4$ (50)
Fumarate

F	η_{25}
0.1	1.060
0.25	1.152
0.5	1.307

$Na_2C_4H_4O_4$ (50)
Succinate

0.1	1.068
0.25	1.175
0.5	1.375

$Na_2C_4H_4O_4$ (50)
Isosuccinate

0.1	1.072
0.25	1.177
0.5	1.373

$Na_2C_4H_4O_5$ (50)
Malate

0.1	1.062
0.25	1.167
0.5	1.363

$Na_2C_4H_4O_6$
Tartrate

F	η_{18} (57)	η_{25} (50, 62)
0.1	1.047	1.055
0.25	1.137	1.146
0.5	1.318	1.322
1	1.790	

$Na_2C_5H_4O_4$ (50)
Itaconate

F	η_{25}
0.1	1.094
0.25	1.211
0.5	1.365

$Na_2C_5H_4O_4$ (50)
Citraconate

0.1	1.076
0.25	1.191
0.5	1.409

$Na_2C_5H_4O_4$ (50)
Mesaconate

0.1	1.074
0.25	1.187
0.5	1.405

$Na_2C_5H_6O_4$ (50)
Pyrotartrate

0.1	1.084
0.25	1.214
0.5	1.457

$Na_2C_6H_8O_4$ (50)
Adipate

0.1	1.088
0.25	1.230
0.5	1.526

$Na_2C_8H_4O_4$ (50)
Phthalate

0.1	1.085
0.25	1.219
0.5	1.464

$Na_2C_8H_4O_4$ (50)
Isophthalate

0.1	1.080
0.25	1.208
0.5	1.457

$Na_2C_8H_4O_4$ (50)
Terephthalate

F	η_{25}
0.1	1.077
0.25	1.201

$Na_2C_8H_{12}O_4$ (50)
Suberate

0.1	1.105
0.25	1.285

$Na_2C_9H_{14}O_4$ (50)
Azelate

0.1	1.164
0.25	1.412

$Na_3C_6H_5O_7$ (50)
Citrate

0.05	1.050
0.1	1.102
0.25	1.272

$Na_4C_{11}H_2O_{10}$ (60)
Benzenepenta-carboxylate

F	η_0	η_{25}
0.005		1.0101
0.02	1.0314	1.0336
0.05	1.0748	1.0758

F	η_{50}
0.05	1.0753

$Na_5C_{11}HO_{10}$ (60)
Benzenepenta-carboxylate

$Na_5C_{11}HO_{10}$—(*Cont'd*)

F	η_0	η_{25}
0.005		1.0125
0.02		1.0378
0.05	1.0850	1.0879

F	η_{50}
0.05	1.0857

$NaC_2H_2ClO_2$
Chloroacetate

F	η_{15} (81)	η_{25} (16)
0.1		1.035
0.2		1.071
0.25	1.086	
0.5	1.174	
1	1.364	

$NaC_2Cl_3O_2$ (81)
Trichloroacetate

F	η_{15}
0.5	1.215

$NaC_7H_4ClO_2$ (50)
m-Chlorobenzoate

F	η_{25}
0.1	1.054
0.25	1.136
0.5	1.282
1	1.621

$NaC_7H_4BrO_2$ (50)
m-Bromobenzoate

0.1	1.053
0.25	1.139
0.5	1.293

$NaC_7H_4BrO_2$ (50)
p-Bromobenzoate

F	η_{25}
0.1	1.055
0.25	1.141
0.5	1.292

$NaC_7H_4NO_4$ (50)
o-Nitrobenzoate

0.1	1.054
0.25	1.136
0.5	1.285
1	1.628

$NaC_7H_4NO_4$ (66)
m-Nitrobenzoate

0.1	1.052
0.25	1.130
0.5	1.269
1	1.606

$NaC_7H_4NO_4$ (50)
p-Nitrobenzoate

0.1	1.031
0.25	1.089
0.5	1.220

$NaC_8H_4NO_2$ (50)
m-Cyanobenzoate

0.1	1.050
0.25	1.128
0.5	1.269

$Na_2O.xSiO_2$ (86)

Viscosity in centipoises at 20°C

The solutions employed in determining the data for the following table were commercial solutions of sodium silicate. The only sample completely analyzed was $Na_2O.2.06SiO_2$; for this the following analysis is given: Na_2O, 18.42%; SiO_2, 36.84%; Al_2O_3, 0.23%; Fe_2O_3, 0.16%; CaO, 0.14%; MgO, 0.05%. The compositions given in the table below refer to the percentages by weight of $Na_2O.xSiO_2$. For given values of x the original data lie on fairly smooth curves which were interpolated to round concentrations. But for a given percentage composition, particularly in the less concentrated solutions, the viscosity data considered as a function of x are quite irregular and it did not seem practicable to smooth them. This effect may be due to varying amounts of impurities in the different solutions.

% \ x	3.90	3.36	2.44	2.06	1.69
3.0	3.3	4.2	3	3	
5.0	4.4	5.5	3.5	4.5	3
10.0	6.5	7.3	5.2	7.5	5.5
15.0	9.0	9.0	7.0	10.0	7.5
20.0	12	12	9	12	10.5
25.0	18	16	12	16	15
28.0	28	22	15	19	19
30.0	49	27	19	22	23
32.0	180	37	24	27	29
33.0	800	44	27	31	34
33.60	7 026				
34.0		55	30	35	39
36.0		120	43	48	58
38.0		270	72	70	95
39.0		460	95	90	120

$Na_2O.xSiO_2$.—(*Continued*)

% \ x	2.44	2.06	1.69	% \ x	
40.0	130	120	150	50.76	8 496*
42.0	210	190	250	51.60	6 115†
44	400	310	430	52.36	22 900*
46	900	550	750	55.26	87 080†
47		750	1050		

* $x = 1.69$. † $x = 2.06$.

Viscosity at 25° (53.5)

F \ x	0	0.5	1.0	2.0	2.5
0.5	1.22	1.28	1.31	1.42	1.49
1.0	1.50	1.70	1.86	2.18	2.50
1.25	1.67	1.93	2.21	2.81	3.43
1.5	1.86	2.30		3.80	4.70

F \ x	3.0	3.3	3.8	3.95	4.2
0.5	1.61	1.68	1.79	1.90	1.87
1.0	3.19	3.48	4.87	5.49	6.77
1.25	4.60	5.42	9.79	13.4	
1.5	7.32	9.38	27.65	104	

$F = 1.5$

x \ t, °C	20	25	40
0.5	2.35	2.30	2.15
2.0	3.95	3.80	3.33
3.95	121.6	103.6	50.1

There is considerable discrepancy between the values at 20° and 25°, probably due to the difference in previous history of the solutions.

Na_4SiO_4 (51)

F	η_{30}
1	2.89

Na_2CrO_4 (82)

F	η_{10}	η_{15} (78)
0.1		1.039
0.25		1.101
0.5	1.24	1.209
1	1.66	
F	η_{20}	η_{30}
0.5	1.25	1.255
1	1.65	1.645
F	η_{40}	
0.5	1.26	
1	1.645	

$Na_2Cr_2O_7$ (78)

F	η_{15}
0.1	1.020
0.25	1.050

Na_2WO_4 (51)

F	η_{30}
1	1.645

KOH

See also (102)

F	η_{18} (57)
0.1	1.009
0.25	1.024
0.5	1.050
1	1.106
2	1.230
4	1.541
7.5	2.325

KOH.—(*Cont'd*)

F	η_{25} (43)	η_{60} (24)
0.1	1.013	1.013
0.25	1.031	1.032
0.5	1.064	1.065
1	1.128	1.134
2	1.268	1.275

KF (72)

F	η_{18}
0.2	1.0258
0.5	1.0674
1.0	1.1348
1.5	1.2066
3.0	1.462
6.0	2.083

KCl

0° (91, 97); 15° (6, 12, 65, 91); 18° (2, 6, 12, 22, 28, 59, 84, 98); 25° (31, 69, 91, 95); 35 and 45° (65, 84)

F	Values of η					
	0°	15°	18°	25°	35°	45°
0.1	0.9945*	0.997†	0.9982*	0.999†	1.001‡	1.003‡
0.25	0.9805*	0.991†	0.9949*	0.998†	1.003‡	1.008‡
0.5	0.9575*	0.984†	0.9898*	0.997†	1.007‡	1.015‡
0.75	0.9423*	0.978†	0.9849*	0.996†	1.011‡	1.023‡
1.0	0.9286*	0.974†	0.9816*	0.995†	1.015‡	1.031‡
1.5	0.909§	0.969‡	0.980‡	0.997‡	1.025§	1.048§
2.0	0.895§	0.968‡	0.982‡	1.002‡	1.035§	1.065§
2.5	0.89§	0.970‡	0.987‡	1.010‡	1.05§	1.085§

KCl.—(*Continued*)

F	Values of η					
	0°	15°	18°	25°	35°	45°
3.0	0.885§	0.975‡	0.994‡	1.021‡	1.065§	1.105§
4.0	0.885§	0.994‡	1.017‡	1.050‡	1.10§	1.145§

* ±0.001. † ±0.002. ‡ ±0.003. § ±0.01.

$KClO_3$ (65, 79); for 18° (72)

F	Values of η				
	15°	18°	25°	35°	45°
0.1	0.994*	0.998†	0.999*	0.999*	1.002‡
0.2	0.990*	0.995†	0.998*	0.999*	1.004‡
0.3	0.987*	0.992†	0.996*	1.000*	1.006‡
0.5	0.981	0.985			

* ±0.003. † ±0.002. ‡ ±0.005.

KBr (84); for 0° (91); for 18° (22, 72, 84, 91); for 25° (31, 91)

F	Values of η							
	0°	5°	10°	18°	25°	40°	50°	60°
0.25				0.986*	0.992			
0.5				0.974*	0.984			
1	0.913	0.925	0.94	0.954*	0.969	1.005	1.02	1.04
2	0.845	0.875	0.905	0.930*	0.959	1.025	1.05	1.08
3	0.817				0.967			
4.5		0.87	0.905	0.952	1.007	1.10	1.145	1.19
5.5					1.050			

* ±0.003.

KI for 0° (40, 91); for 5°, 10°, 40°, 50°, 60° (84); for 18° (2, 22, 28, 84); for 25° (31, 40, 84, 91)

F	Values of η							
	0°	5°	10°	18°*	25°	40°	50°	60°
0.1	0.982*			0.9908	0.993			
0.25				0.9768	0.981			
0.5		0.940	0.947	0.9561	0.964	0.990	1.001	1.009
1	0.860	0.893	0.906	0.9228	0.936	0.983	1.004	1.020
2	0.787			0.898	0.915			
3	0.755	0.81	0.845	0.892	0.916	0.989	1.035	1.075
5		0.805	0.855	0.916	0.951	1.048	1.105	1.16
7		0.865	0.91	0.978	1.03	1.149	1.21	1.285
7.5				1.003				
9					1.20			

* ±0.001.

	$KBrO_3$ (80)	KIO_3 (28, 72)			$KHSO_4$ (57)			
F	0.25	0.1	0.2	0.3	0.25	0.5	1	2
η_{15}	0.994							
η_{18}		1.0141	1.0278	1.042	1.035	1.071	1.144	1.310

K_2SO_4 (84, 92); for 18° (2, 28, 57, 84, 92); for 25° (95)

F	Values of η					
	10°*	18°†	25°*	30°*	40°*	50°*
0.05		1.011	1.011			
0.1	1.017	1.021	1.022	1.023	1.024	1.025
0.25	1.044	1.051	1.054	1.057	1.062	1.065
0.5	1.087	1.0995	1.109	1.118	1.128	1.136

* ±0.005. † ±0.001

KN_3 (11)

F	Values of η				
	0°	25°	35°	50°	75°
1	0.945	1.006	1.019	1.035	1.053
3	0.926	1.043	1.075	1.120	1.171
4	0.939	1.077	1.116	1.172	1.237
6		1.188	1.231	1.297	1.383

KNO_3

F	η_{10} (84)	η_{40} (84)
1	0.948	1.01
2	0.94	1.04

F	η_{18} (2, 22, 28, 59, 84)	η_{25} (84, 95)
0.1	0.9941	0.995
0.25	0.9857	0.989
0.5	0.9748	0.982
1	0.9630	0.976
2	0.975	0.999

F	η_{50} (84)	η_{60} (84)
1	1.02	1.035
2	1.06	1.085

K_3PO_4 (57)

F	η_{18}
0.1	1.050
0.25	1.130
0.5	1.292
1	1.721

K_2HPO_4 (57)

0.1	1.034
0.25	1.091
0.5	1.201
1	1.513
2	2.18

KH_2PO_4 (57)

0.25	1.064
0.5	1.137
1	1.291

K_2CO_3 (2, 57, 72)

F	η_{18}	η_{25}† (43)
0.1	1.029*	1.031
0.25	1.073*	1.078
0.5	1.152*	1.165
1	1.340*	
2	1.82	
3	2.46	
4	3.34	

* ±0.003.
† ±0.005.

$K_2C_2O_4$ (28, 57)
Oxalate

F	η_{18}
0.05	1.0125
0.1	1.0235
0.25	1.0545
0.5	1.110
1	1.225

$KHCO_3$ (57)

0.25	1.029
0.5	1.059
1	1.123
2	1.261

$KHCO_2$ (81)
Formate

F	η_{15}
0.5	1.039

$KC_2H_3O_2$ (2, 72, 81)
Acetate

F	η_{18}
0.1	1.028
0.25	1.064
0.5	1.125
1	1.248
2	1.515
3	1.817
4	2.172

$KC_3H_5O_2$ (81)
Propionate

F	η_{15}
0.5	1.164

$K_2C_4H_4O_6$ (44, 57)
Tartrate

F	η_{18}
0.25	1.078
0.5	1.183
0.75	1.30
1.5	1.74

$KC_2Cl_3O_2$ (81)
Trichloroacetate

F	η_{15}
0.5	1.164

KC_2H_2ClO (81)
Chloroacetate

0.5	1.106

KCNS

F	η_{18} (72)
0.1	0.997
0.25	0.989
0.5	0.977
1	0.960
2	0.950
5	1.036

F	η_{25} (99)
1	0.970

F	η_{75} (99)
1	1.020

$K_3Fe(CN)_6$

F	$\eta_{1.6}$ (65)
0.1	0.988
0.25	0.990

F	η_{15} (65)	η_{25} (65, 95)
0.1	1.007*	1.016*
0.25	1.022*	1.044*
0.5	1.062*	1.098*

* ±0.003.

$K_4Fe(CN)_6$

0.1	1.035	1.045
0.25	1.091	1.113
0.5	1.202	1.236

K_2CrO_4

F	η_{10} (84)	η_{18} (72, 78)
0.1		1.105
0.25		1.038
0.5		1.078
1	1.13	1.174
2	1.35	1.425

F	η_{30} (84)	η_{40} (84)
1	1.20	1.23
2	1.47	1.51

K_2CrO_4—(*Cont'd*)

F	η_{50} (84)
1	1.25
2	1.54

$K_2Cr_2O_7$

F	η_{10} (82)	η_{25} (43)
0.1	0.993	1.001
0.25	0.986	1.006

F	η_{40} (82)
0.1	1.008
0.25	1.024

$KNaC_4H_4O_6$ (57)
Tartrate

F	η_{18}
0.25	1.108
0.5	1.246
0.75	1.410
1.5	2.05

RbOH (20)

F	η_{25}
0.1	1.009
0.25	1.023
0.5	1.048
1	1.103

RbCl

F	η_5* (76)	η_{10}* (76)
0.25	0.975	0.982
0.5	0.955	0.967
1	0.923	0.941

F	η_{18} (72, 76)	η_{25}* (76, 95)
0.25	0.990†	0.995
0.5	0.980†	0.990
1	0.965†	0.983
2	0.943	

* ±0.003. † ±0.002.

RbBr (14)

F	η_{25}	η_{35}
0.1	0.995	0.999
0.25	0.989	0.998
0.5	0.979	0.997

F	η_{45}
0.1	1.001
0.25	1.004
0.5	1.015

RbI (23)

F	η_{25}
0.25	0.978
0.5	0.957
1	0.921
2	0.877
3	0.873
3.5	0.883

Rb_2SO_4; *v. next column*

CsCl

F	η_{18} (72)	η_{25} (39, 95)
0.25	0.986*	0.992
0.5	0.973*	0.985
1	0.952*	0.975
2	0.927	

* ±0.002.

Rb_2SO_4 (93)

F	Values of η				
	10°	20°	30°	40°	50°
0.1	1.005	1.011	1.017	1.021	1.027
0.25	1.016	1.03	1.043	1.053	1.067
0.5	1.040	1.07	1.090	1.105	1.129
1.0	1.113	1.15	1.19	1.21	1.25

Cs_2SO_4 (93)

F	Values of η				
	10°	20°	30°	40°	50°
0.1	1.008	1.012	1.016	1.020	1.026
0.25	1.022	1.031	1.040	1.050	1.061
0.5	1.047	1.067	1.082	1.099	1.117
1.0	1.105	1.145	1.170	1.197	1.23

$CsNO_3$ (55)

F	Values of η			
	0°	10°	18°	25°
0.025	0.9960	0.9973	0.9984	0.9986
0.05	0.9902	0.9938	0.9961	0.9971
0.1	0.9796	0.9870	0.9910	0.9932
0.2	0.9612	0.9742	0.9808	0.9853
0.3	0.9445	0.9618	0.9715	0.9784
0.4	0.9288	0.9510	0.9632	0.9723
0.5		0.9413	0.9559	0.9668
0.6		0.9324	0.9494	0.9621
0.7		0.9239	0.9434	0.9579
0.8			0.9377	0.9540

AQUEOUS SOLUTIONS CONTAINING TWO STRONG ELECTROLYTES

ℬ-TABLE; Standard Arrangement (*v.* Vol. III, p. viii)

A	B	t, °C	Lit.
HCl	$CdCl_2$	25	(43)
	$HgCl_2$	25	(43, 101)
	$CuCl_2$	25	(101)
	$FeCl_3$	25	(43)
	$CoCl_2$	25	(101); *cf.* (103)
	NaCl	25	(69)
	KCl	25	(69)
H_2SO_4	HNO_3	10	(3)
		20	(3)
		40	(3)
	$K_2Cr_2O_7$	25	(43)
HNO_3	$Ba(NO_3)_2$	25	(43)
NH_4NO_3	NH_4Cl	25	(43)
	$Pb(NO_3)_2$	25	(43)
	$Ba(NO_3)_2$	25	(43)
	$NaNO_3$	25	(43)
	KNO_3	25	(43)
NH_4Cl	$FeCl_3$	25	(43)
	$BaCl_2$	25	(43)
	NaCl	15	(12)
		20	(12)
	KCl	15	(12)
		20	(12)
		25	(43)
$(NH_4)_2SO_4$	$CuSO_4$	25	(43)
	$MnSO_4$	25	(43)
	$Al_2(SO_4)_3$	25	(43)
	K_2SO_4	25	(43)

B-Table.—(*Continued*)

A	B	*t*, °C	Lit.
$Pb(NO_3)_2$	$NaNO_3$	25	(43)
	KNO_3	25	(43)
$CuCl_2$	$MgCl_2$	25	(101)
	LiCl	25	(101)
	NaCl	25	(101)
	KCl	25	(101)
$CuSO_4$	$MnSO_4$	25	(43)
	Na_2SO_4	25	(43)
	K_2SO_4	25	(43)
$MnSO_4$	Na_2SO_4	25	(43)
	K_2SO_4	25	(43)
$CoCl_2$	$MgCl_2$	25	(101)
	LiCl	25	(101)
	NaCl	25	(101)
	KCl	25	(101)
$Al_2(SO_4)_3$	Na_2SO_4	25	(43)
	K_2SO_4	25	(43)
$MgCl_2$	$NaNO_3$	20	(59)
$Mg(NO_3)_2$	NaCl	20	(59)
	KNO_3	20	(59)
$CaCl_2$	NaCl	20	(59)
	$NaNO_3$	20	(59)
$Ca(NO_3)_2$	$NaNO_3$	20	(59)
$SrCl_2$	NaCl	20	(59)
	KNO_3	20	(59)
$Sr(NO_3)_2$	$NaNO_3$	20	(59)
		25	(43)
	KCl	20	(59)
	KNO_3	20	(59)
		25	(43)
$BaCl_2$	$Ba(NO_3)_2$	25	(43)
	NaCl	15	(12)
		20	(12, 59)
		25	(43)
	KCl	25	(43)
$Ba(NO_3)_2$	$NaNO_3$	25	(43)
	KNO_3	25	(43)
NaOH	KOH	25	(43)
NaCl	$NaNO_3$	25	(43)
	KCl	15	(12)
		20	(12)
		25	(43, 69, 85)
NaI	KI	25	(85)
Na_2SO_4	K_2SO_4	25	(43)
$NaNO_3$	KNO_3	25	(43)
Na_2CO_3	K_2CO_3	25	(43)
Na_2SiO_3	Na_2WO_4	30	(51)
KCl	KNO_3	25	(43)
K_2SO_4	$K_2Cr_2O_7$	25	(43)

For solutions containing NH_4OH and various salts, *v.* (4, 5, 43).

AQUEOUS SOLUTIONS CONTAINING THREE OR MORE STRONG ELECTROLYTES

		Lit.
$HCl + NaCl + KCl$	25°	(69)
$MgCl_2 + CaCl_2 + SrCl_2 + NaNO_3$	20°	(59)
$MgCl_2 + Sr(NO_3)_2 + Ba(NO_3)_2$	20°	(59)
$Mg(NO_3)_2 + Ca(NO_3)_2 + NaCl$	20°	(59)
$Mg(NO_3)_2 + Sr(NO_3)_2 + KCl + KNO_3$	20°	(59)
$Mg(NO_3)_2 + SrCl_2 + NaCl + KNO_3$	20°	(59)

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VISCOSITY OF AQUEOUS SOLUTIONS OF WEAK ELECTROLYTES AND OF ALL ORGANIC ACIDS AND BASES

M. P. APPLEBEY

F = Gram-formula-weight, η = Viscosity, η_w = Viscosity relative to water at the same temperature.*

Weak Bases

NH_3	F/l	1	2	4	6	8	Lit.
25°	$\eta/\eta_w \pm 0.5\%$	1.020	1.040	1.081	1.121	1.169	(3)

AMINES

Values of $\eta/\eta_w \pm 0.005$ at 25° C (24)

F/l	0.125	0.25	0.5	1.0
NH_3 (for comparison)	1.003	1.006	1.0105	1.0245
CH_3NH_2	1.017	1.034	1.082	1.155
$(CH_3)_2NH$	1.030	1.063	1.144	1.304
$(CH_3)_3N$	1.068	1.143	1.299	1.684
$(CH_3)_4NOH$	1.035	1.072	1.146	1.316

C_5H_5N, PYRIDINE (4, 14, 15, 19, 21, 26)

Values of $\eta/\eta_w \pm 0.3\%$ at 0 and 25°; $\pm 1\%$ at 18°; $\pm >1\%$ at higher temperatures. Maxima at 63% for 0° and 66% for 25°

t, °C \ Wt. %	20	40	60	80	100
0	1.790	2.560	3.120	2.410	0.745
18	1.580	2.375	2.570	2.155	0.925
25	1.530	2.065	2.475	2.140	0.995
55	1.39	1.74	2.02	1.96	1.18
77	1.25	1.55	1.82	1.83	1.35
100	1.20	1.43	1.69	1.83	1.41

Amino Acids (22)

Values of $\eta/\eta_w \pm >0.002$

Formula	Name	t, °C \ F/l	0.25	0.5	1.0	2.0
CH_2NH_2COOH	Glycocoll	18		1.070	1.153	1.362
		40		1.074	1.165	
$CH_3CH(NH_2)COOH$	Alanine	18	1.059	1.133	1.310	
		40		1.127	1.281	
$C_6H_5CH_2CH(NH)_2$-COOH	Phenyl-alanine	18	8.31 g/l.	η/η_w = 1.027.		

Monocarboxylic Acids

CO_2, CARBON DIOXIDE (30)

η/η_w for the saturated solution at 20° = 1.007.

HCO_2H, FORMIC ACID (2, 5, 11, 17, 18, 27, 31, 36, 38)

Values of η in millipoises†

t, °C \ Wt. %	20	40	60	80	90	100
15	12.75	13.90	15.60	17.95	19.20	19.85
20	11.10	12.50	14.10	16.10	17.10	17.90
25	10.10	11.30	12.85	14.65	15.55	16.05
35	8.25	9.35	10.70	12.20	12.95	13.35
45	6.90	7.85	9.05	10.30	10.85	11.25
55	5.85	6.76	7.75	8.80	9.30	9.60
65	5.10	5.70	6.75	7.70		
75	4.45	5.15	5.95	6.80		
85	3.90	4.55	5.25	6.05		

F/l	0.1	0.25	0.5	1.0	Lit.
η/η_w, 25°	1.004	1.009	1.017	1.031	(31)

* All interconversions between η and η/η_w have been based upon the values for water given on p. 10.

† $\pm$ *ca.* 1 % at 25°; > 1 % at higher temperatures.

CH_3CO_2H, ACETIC ACID (2, 32, 34, 40)

Values of η in millipoises, $\pm 0.5\%$ for low, and $\pm(2\text{–}3)\%$ for high concentrations and temperatures

t, °C \ Wt. %	10	20	30	40	50	60	70	75	90	100
15	13.60	16.30	19.10	21.60	24.75	27.65	30.20	31.05	26.80	13.50
20	12.10	14.15	16.35	18.70	21.35	23.90	26.40	26.95	23.10	12.65
25	10.65	12.50	14.50	16.55	18.70	20.85	22.90	23.65	20.50	11.55
30	9.55	11.10	12.90	14.75	16.60	18.50	20.40	20.95	18.40	10.65
35	8.55	10.00	11.50	13.15	14.80	16.50	18.15	18.55	16.55	9.90
40	7.80	9.05	10.40	11.80	13.25	14.70	16.20	16.60	14.90	9.25
45	7.10	8.20	9.40	10.60	11.85	13.20	14.45	14.85	13.45	8.65
50	6.50	7.45	8.55	9.65	10.80	11.90	13.05	13.40	12.25	8.10
55	6.00	6.80	7.75	8.80	9.85	10.80	11.95	12.15	11.25	7.60
60	5.50	6.25	7.10	8.00	9.00	9.95	10.90	11.05	10.30	7.00
65	5.05	5.75	6.55	7.35	8.20	9.00		10.10		6.75
75	4.40	4.95	5.60	6.30	7.00	7.65		8.55		6.05
85	3.85	4.35	4.90	5.45	6.05	6.60		7.40		5.45
95	3.40	3.85	4.30	4.75	5.30	5.75		6.40		4.90

η/η_w, 25° $= [1 + 0.1104\,F/l + 0.00208\,(F/l)^2] \pm 0.002$
η/η_w, 18° $= [1 + 0.1169\,F/l + 0.0013\,(F/l)^2] \pm >0.002$
} up to $3N$.

$ClCH_2CO_2H$, MONOCHLOROACETIC ACID (7)

F/l	0.1	0.25	0.5	1.0	2.0	3.0	3.84	
η/η_w, 25°	1.018	1.045	1.088	1.161	1.330	1.536	1.717	±0.002

Cl_2CHCO_2H, DICHLOROACETIC ACID (24)

F/l	0.1	0.25	0.5	1.0	
η/η_w, 25°	1.024	1.064	1.131	1.265	±0.005

Cl_3CCO_2H, TRICHLOROACETIC ACID (6)

η/η_w, 25° $= (1 + 0.355n) \pm 0.002$, up to $n = \frac{1}{2}$ normal.

$CH_3CHClCCl_2CO_2H$, TRICHLOROBUTYRIC ACID (6)

η/η_w, 25° $= (1 + 0.435n) \pm 0.002$ up to $n = 0.2N$.

$CH_3CH_2CO_2H$, PROPIONIC ACID

F/l		0.1	0.25	0.5	1.0	1.5	2.0		
η/η_w	18°	1.019	1.048	1.096	1.191	1.291	1.392	±0.002	(31, 40)
	25°	1.019	1.048	1.098	1.098	1.310	1.430		

η in millipoises ($\pm 2\%$ at 20°)

t, °C \ Wt. %	10	30	50	70	90	100	Lit.
20	12.95	18.65	24.0	28.05	26.4	11.2	(38)
40	8.6	11.9	15.5			9.0	(37)
60	6.2	8.4	10.35			7.35	(37)

$C_4H_8O_2$, BUTYRIC ACID

F/l		0.1	0.25	0.5	1.0	(31, 40)
η/η_w, 25°	*n*-	1.025	1.063	1.131	1.280	±0.002
	iso-	1.026	1.066	1.129	1.273	±0.003

$CH_3CH_2CH_2CO_2H$, *n*-BUTYRIC ACID

η in millipoises, $\pm$ several %, max. at *ca.* 72% for 20°

t, °C \ Wt. %	10	30	50	75	100	Lit.
20	13.6	22.3	31.3	36.0	16.0	(37, 38)
40	8.5	13.3	17.9		11.8	(37)
60	6.3	9.0	12.0		9.1	(37)

$(CH_3)_2CHCO_2H$, Isobutyric Acid

$\eta/\eta_w \pm 0.5\%$ (16)

t, °C \ Wt. %	10	20	30	40	50	60	100
20	1.340	1.765	Two liquid phases				1.305
25	1.320	1.725				3.225	1.355
30		1.685	2.210	2.720	2.990	3.120	1.400
35		1.660	2.130	2.590	2.890	3.030	1.445
40		1.625	2.065	2.480	2.780	2.945	1.485

$CH_3CH(OH)CO_2H$, Lactic Acid (10, 31)

$\frac{1}{2}F/l$	0.1	0.25	0.5	1.0
η/η_w, 25°, ±0.003	1.0255	1.0585	1.119	1.250

Wt. %	10	30	50	70	100
η/η_w, 25°, ±0.1%	1.270	2.020	3.67	7.2	45.3

$(CH_3)_2CHCH_2CO_2H$, Isovaleric Acid (31)

η/η_w, 25° $= (1 + 0.300n) \pm 0.003$; up to $n = 0.25N$.

$C_6H_5CH(OH)CO_2H$ *d-*, *l-*, or *dl*-Mandelic Acid (13)

Wt. %	2	4	6	8	10	
η/η_w, 25°	1.047	1.106	1.171	1.240	1.315	±0.002

Dicarboxylic Acids

HO_2CCO_2H, Oxalic Acid

F/l	0.1	0.25	0.5	1.0		
η/η_w, 18°	1.018	1.045	1.090	1.200	±0.003	(23, 38)

$HO_2CCH_2CH_2CO_2H$, Succinic Acid (23)

$\frac{1}{2}F/l$	0.1	0.25	0.5	1.0		
η/η_w 18°	1.010	1.026	1.052	1.109	±0.005	(28, 33)
η/η_w 25°	1.012	1.029	1.058	1.117	±0.002	(28, 33)

$HO_2CCH(OH)CH(OH)CO_2H$, Tartaric Acid (28)

F/l	0.1	0.25	0.5	1.0	1.5	
η/η_w, 18°	1.029	1.072	1.153	1.400	1.712	±0.004

At 25°, η/η_w for a 13.04 Wt. % solution = 1.401 for the *d-* and 1.388 for the *dl*-acid (13).

$HO_2CCH(CH_3)CH_2CO_2H$, Methylsuccinic Acid (33)

$\frac{1}{2}F/l$	0.1	0.25	0.5	
η/η_w, 25°	1.0145	1.037	1.078	±0.002

$CH_2:C(CO_2H)CH_2CO_2H$, Itaconic Acid (33)

η/η_w, 25° $= (1 + 0.143n) \pm 0.001$ up to $n = 0.34N$.

$HO_2CCH(OCOCH_3)CH(OCOCH_3)CO_2H$, Diacetyltartaric Acid (8)

$\frac{1}{2}F/l$	0.1	0.25	0.5	1.0	
η/η_w, 25°	1.026	1.067	1.142	1.308	±0.003

Sulfonic Acids and Phenol

$CH_3C_6H_4SO_3H$, *p*-Toluenesulfonic Acid (6)

η/η_w, 25° $= (1 + 0.435n) \pm 0.02$ up to $n = 0.2N$.

$(CH_3)_3C_6H(NH_2)SO_3H$, Trimethylsulfanilic Acid (25)

η/η_w, 25° $= (1 + 0.0148 \times$ Wt. %) up to 2% acid.

C_6H_5OH, Phenol

F/kg soln	0.1	0.25	0.5	(20)
η/η_w, 18°	1.019	1.049	1.101	±0.004

$\eta/\eta_w \pm 0.5\%$ up to 80°; less accurate above 80° (1, 16, 35)

t, °C \ Wt. %	10	20	35	50	65	80	100
50	1.195	Two liquid phases			3.065		6.39
60	1.185				2.855		5.64
67.5	1.175	1.475	2.135	2.560	2.745	3.275	5.16
75	1.170	1.455	1.945	2.365	2.640	3.160	4.78
80	1.170	1.420	1.880	2.285	2.575	3.085	4.59
85	1.165	1.400	1.855	2 200	2.550	3.010	
90		1.385		2.180			
95		1.355		2.125			

SYSTEMS WITH TWO SOLUTES

Water—acetic acid—toluene (41).
Water—methyl or ethyl alcohol—picric acid (19.1).
Water—methyl or ethyl alcohol—aniline (19.1).
Water—methyl or ethyl alcohol—toluidine (19.1).
Water—methyl or ethyl alcohol—piperidine (19.1).

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(For key to the periodicals see end of volume)

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VISCOSITY OF AQUEOUS SOLUTIONS OF NON-ELECTROLYTES

Guy Barr

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Systems containing but one solute	22
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Systems containing two solutes, one an electrolyte and the other a non-electrolyte	24
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ABBREVIATIONS

F = Gram-formula-weight
η = Viscosity
η/η_w = Viscosity relative to water at the same temperature.*

* All interconversions between η and η/η_w have been based upon the values for water given on p. 10.

INTRODUCTION

Throughout this section where a table is given under the name of one author only, it may be assumed, unless the contrary is stated:

1. That a viscometer of the Ostwald type was used for the determinations, no mention having been made by the experimenter of a test for the compliance of his instrument with Poiseuille's law, and no kinetic energy correction having been applied to the results. The abbreviation (K. E.) indicates that a kinetic energy correction has been applied.

2. That the mixtures were made up by weight without reduction *ad vacuum*.

In the majority of cases the purity of the solute is of prime importance in determining the viscosity of the solutions; melting

points, boiling points, etc., are therefore quoted where such details are given. The viscosities tabulated for the pure liquid non-electrolytes may be found to differ from the I. C. T. values for the pure liquids, but it is not possible, in general, to adjust the tables to remove the discrepancy.

Systems Containing But One Solute

C-Arrangement (*v.* Vol. III, p. viii)

CH_3NO, Formamide, $HCONH_2$

η in millipoises (11, 30, 44)

Wt. %	0.0	20.0	40	60	80	100
η_{25}	8.9	10.0	11.6	14.6	20.7	32.7

CH_4O, Methyl Alcohol, CH_3OH

(B. P., 64.9°C); η in millipoises (K. E.) (5)

Wt. % \ t, °C	25	35	45	55
21.41	14.23	10.89	8.58	7.02
47.36	15.61	11.99	9.47	7.74
71.61	11.89	9.57	7.80	6.52
100.00	5.48	4.76	4.17	3.71

Specially Dried Alcohol

η in millipoises (42)

Wt. %	84.86	88.79	91.90	95.35	97.52	98.77	99.24	100.0
η_{15}	11.20	10.03	8.98	7.88	7.14	6.76	6.57	6.34

CH_4N_2O, Urea, $CO(NH_2)_2$ (33)

$F/1$	0.25	0.5	1.0	2.0	4.0	8.0
η/η_w, 20°	1.010	1.022	1.039	1.088	1.215	1.655

(M. P., 132°C); η in millipoises (11)

Wt. %	1.02	8.13	11.89	15.47	23.12	33.28	38.13	46.18
η_{25}	8.99	9.43	9.73	10.40	10.93	12.57	13.54	15.68

C_2HCl_3O, Chloral, Cl_3CCHO

Solutions up to 50M % made from the hydrate ($d_4^{50} = 1.6193$); above 50M % from chloral (B. P., 97.0–97.2°C), ($d_4^{25} = 1.5049$) (27)

Mole % C_2HCl_3O	η in millipoises				
	50°	60°	70°	85°	90°
0.0	5.49	4.70	4.07	3.36	3.17
2.0		5.95		4.20	
5.0	10.33	8.41	6.87	5.50	4.75
10.0	17.35	13.97	10.80	8.41	7.39
15.0	26.77	20.97	16.25	11.80	10.27
20.0	41.65	31.00	22.84	16.17	13.65
25.0	60.00	43.58	30.04	20.34	16.97
30.0	87.70	57.79	37.62	23.96	19.67
35.0	113.86	72.39	45.39	27.06	21.77
40.0	143.57	85.74	50.80	28.52	22.56
42.5	156.07	90.50	51.63	29.02	22.35
45.0	164.06	91.72	51.51	28.43	21.44
46.5	170.98	90.91	50.65	27.47	21.05
47.5	174.21	90.17	50.27	26.59	20.61
49.0	172.99	88.19	48.66	25.58	
50.0	167.55	86.82	47.86	24.81	19.61
55.0	141.04	75.79	40.72	21.70	
60.0	114.17	60.45	34.04	18.79	
70.0	57.07	34.07	21.60	13.11	
80.0	26.87	18.52	13.57	9.04	
90.0	14.50	11.55	9.73	6.56	
100.0	8.71	7.82	6.79	5.58	5.24

C_2H_5NO, Acetamide, CH_3CONH_2

M. P., 82°C; η in millipoises (11)

Wt. %	0	0.78	5.82	17.69	25.95	37.21	69.26
η_{25}	8.95	8.94	9.95	12.38	14.65	18.83	44.62

C_2H_5NO.—(*Continued*)

Values of η/η_w (43)

$F/1$ \ t, °C	5	10	15	20	25	30	35	40
0.1	1.089	0.957	0.982	0.996	1.000	1.001	0.985	0.988
0.25	1.161	0.985	1.020	1.013	1.045	1.017	1.012	1.001
0.5	1.179	1.053	1.028	1.027	1.063	1.044	1.025	1.052
0.75	1.293	1.095	1.081	1.069	1.074	1.092	1.043	1.065
1.0	1.344	1.133	1.133	1.103	1.126	1.157	1.128	1.085

C_2H_6O, Ethyl Alcohol, C_2H_5OH (5, 12)

Values of η in millipoises ±0.2% between 20 and 60°C. Solutions near $\eta_{max.}$ may be used for calibration of viscometers if evaporation is avoided.

Wt. % \ t, °C	0	10	20	25	30	40	50	60	70
10	32.15	21.62	15.48	13.28	11.53	8.96	7.25	6.02	5.09
20	52.75	32.35	21.68	18.08	15.39	11.44	8.96	7.28	6.06
30	69.0	40.95	26.70	22.03	18.49	13.53	10.38	8.26	6.77
40	71.5	43.55	28.67	23.74	19.91	14.55	11.16	8.87	7.24
45	70.1	43.1	28.67	23.87	20.07	14.78	11.38	9.02	7.36
50	66.25	41.74	28.32	23.68	20.01	14.75	11.36	9.04	7.39
60	57.15	37.87	26.42	22.32	19.06	14.26	11.09	8.87	7.27
70	47.2	32.68	23.69	20.25	17.44	13.28	10.44	8.41	6.96
80	36.48	26.63	19.98	17.38	15.19	11.81	9.50	7.78	6.48
90	26.94	20.48	16.01	14.22	12.70	10.22	8.35	6.95	5.89
100	17.76	14.80	12.21	11.01	9.97	8.24	6.95	5.90	5.06

$C_2H_6O_2$, Glycol, $(HOCH_2)_2$

($d_0^{25} = 1.1110$); η in millipoises (10)

Wt. %	η_{25}	Wt. %	η_{25}	Wt. %	η_{25}
0.00	8.95	45.13	28.73	69.52	62.54
14.11	12.64	49.55	32.13	75.64	92.42
33.11	16.28	60.84	45.08	100.00	180.9

C_3H_6O, Allyl Alcohol, $CH_2{:}CHCH_2OH$

($d_0^{25} = 0.8500$); η in millipoises (10)

Wt. %	0.00	14.06	25.98	33.70	35.53	36.53	45.21	46.88
η_{25}	8.95	13.55	16.89	17.97	18.42	18.54	18.96	19.03
Wt. %	47.31	47.82	48.56	56.63	65.00	69.56	83.20	100.00
η_{25}	18.95	18.99	19.00	18.99	18.04	17.58	15.44	12.37

C_3H_6O, Acetone, $(CH_3)_2CO$

(B. P., 56.1°C); η in millipoises (K. E.) (3, 31)

Wt. %	0.0	12.2	14.4	23.6	24.7	30.3	40.7
η_{25}	8.95	11.39	11.82	13.15	13.24	13.60	13.43
Wt. %	50.6	61.2	70.9	80.4	89.9	100.0	
η_{25}	12.30	10.25	8.10	6.06	4.37	3.17	
Wt. %	0.0	0.41	0.66	1.81	3.29	9.12	16.76
η_{20}	10.09	10.18	10.26	10.57	10.95	12.55	13.70

η in millipoises ± *ca.* 0.5%; Vol. % at 18–20°C (7, 22)

Vol. % \ t, °C	0	15	25	35	45
0	17.94*	11.45	8.95	7.21	5.97
12.5		14.45	10.90	8.55	6.96
25	29.6*	17.20	12.76	9.81	7.83
37.5		18.43	13.68	10.37	8.26
50	30.6*	17.88	13.35	10.26	8.18
62.5		15.29	11.82	9.13	7.38
75	17.2*	11.26	8.94	7.26	6.02
100	4.1*		3.24*		

* Values marked with * are from (22).

C_3H_7NO, Propionamide, $C_2H_5CONH_2$
(M. P., 80–81°C); η in millipoises [11]

Wt. %	0.00	1.24	5.65	11.71	22.18	41.48	70.65
η_{25}	8.95	9.23	10.30	11.93	15.43	30.43	60.06

C_3H_8O, *n*-Propyl Alcohol, C_3H_7OH
(B. P., 97.7°C); η in millipoises [12]

t, °C \ Wt. %	0.00	17.40	28.62	59.38	73.13	100.00
20	10.09	20.23	25.65	31.69	29.58	21.95
25	8.95	17.04	21.27	26.64	25.20	19.44
30	8.00	14.45	18.18	23.14	21.76	17.42

$C_3H_8O_3$, Glycerol, $C_3H_5(OH)_3$
η in millipoises (K. E.); values of d *in vacuo* [1]

d_{20}^{20}	η_{20}	d_{20}^{20}	η_{20}	d_{20}^{20}	η_{20}
1.0000	10.09	1.1848	235.4	1.2240	1108
1.1014	37.34	1.2057	496.7	1.2463	4093
1.1699	153.6	1.2155	747.8	1.2568	8717

η relative to that of 99.5% glycerol at 25°C [39]; commercial samples of double-distilled glycerol diluted to $d_4^{25} = 1.252$ may, however, differ in η by as much as 8% [2, 25].

d_4^{25}	1.2539	1.2526	1.2520	1.2510	1.2500	1.2480
$10\,\eta/\eta_0^{25}$	10.87	10.00	9.61	8.99	8.40	7.30
d_4^{25}	1.2460	1.2440	1.2420	1.2400	1.2370	1.2340
$10\,\eta\ \eta_0^{25}$	6.35	5.52	4.84	4.26	3.57	3.00

C_4H_9NO, *n*-Butyramide, $C_3H_7CONH_2$
(M. P., 116°C); η in millipoises [11]

Wt. %	0.00	1.02	8.11	16.88	17.92
η_{25}	8.95	9.10	11.27	14.64	15.18

$C_6H_6O_2$, Hydroquinol, *p*-$C_6H_4(OH)_2$ [28]

Wt. %	η/η_{w38}	Wt. %	η/η_{w38}	Wt. %	η/η_{w38}	Wt. %	η/η_{w38}
0.10	1.171	0.75	1.172	2.00	1.234	4.00	1.275
0.25	1.161	1.00	1.206	3.00	1.271	5.00	1.295
0.50	1.167	Scarpa viscometer, $t = 2t_1t_2/(t_1 + t_2)$					

$C_6H_6O_2$, Pyrocatechol, *o*-$C_6H_4(OH)_2$ [28]

Wt. %	η/η_{w38}	Wt. %	η/η_{w38}	Wt. %	η/η_{w38}	Wt. %	η/η_{w38}
0.10	1.132	0.75	1.132	2.00	1.259	4.00	1.263
0.25	1.113	1.00	1.204	3.00	1.238	5.00	1.251
0.50	1.126	Scarpa viscometer, $t = 2t_1t_2/(t_1 + t_2)$					

$C_6H_{12}O_6$, Dextrose

Wt. % *in vacuo*	η in millipoises [37]					
	25°	30°	35°	40°	45°	50°
9.67	11.70	10.38	9.24	8.34	7.52	6.89
18.66	15.86	13.91	12.27	10.89	9.76	8.84
27.08	22.31	19.49	17.00	15.03	13.30	11.93
34.94	33.3	28.80	24.73	21.64	18.98	16.90
42.33	52.4	44.0	37.4	32.2	27.80	24.35
49.33	88.2	72.2	60.2	50.9	42.8	36 9

η/η_w [43]

F/l	5°	10°	15°	20°	25°	30°	35°	40°
0.1	1.212	1.024	1.048	1.027	1.047	1.049	1.013	1.020
0.25	1.363	1.210	1.197	1.186	1.198	1.199	1.169	1.167
0.5	1.450	1.329	1.266	1.289	1.324	1.294	1.237	1.188
0.75	1.739	1.526	1.476	1.447	1.447	1.464	1.411	1.414
1.0	1.889	1.637	1.611	1.621	1.588	1.597	1.528	1.514

Shelton [45] gives η for confectioner's glucose syrup (Corn Products Refining Company) and for mixtures of this with water and pure dextrose:

$C_6H_{12}O_6$.—(*Continued*)

Solution (η in poises)	d_{25}^{25}	η_{25}
1. Original syrup + dextrose	1.470	165000
2. Original syrup + dextrose	1.447	14000
3. Original syrup	1.436	5000
4. Original syrup + H_2O	1.420	764
5. Original syrup + H_2O	1.379	36.6
6. Original syrup + H_2O	1.331	3.7

$C_6H_{12}O_6$, Galactose; η in millipoises [38]

Wt. %	0.00	1.15	2.30	4.60	9.12	18.24
η_{25}	8.95	9.22	9.50	10.06	11.48	15.64

Honey [41].

$C_6H_{12}O_6$, Levulose; η in millipoises [37]

t, °C \ Wt. %	0.00	9.58	18.49	26.96	34.81	42.18	49.07
20	10.09	13.06	17.63	24.44	36.06	56.25	95.6
25	8 95	11.40	15.33	21.04	30.3	46.7	77.2
30	8.00	10.19	13.52	18.37	25.97	39.1	63.5
35	7.21	9.08	11.88	16.15	22.45	33.25	52.8

$C_{12}H_{22}O_{11}$, Lactose; η in millipoises [38]

Wt. %	0.00	1.28	2.78	5.80	11.66	17.06	23.38
η_{25}	8.95	9.28	9.72	10.61	12.97	15.91	21.21

$C_{12}H_{22}O_{11}$, Maltose; η in millipoises [38]

Wt. %	0.00	1.16	2.32	4.77	9.60	19.40
η_{25}	8.95	9.31	9.66	10.35	12.26	18.12

$C_{12}H_{22}O_{11}$, Sucrose
η in millipoises (K. E.). Wt. % *in vacuo;* solutions suitable for standardization of viscometers [4]

t, °C \ Wt. %	20	40	60	t, °C \ W %	20	40	60
0	38.18	148.2		50	9.74	25.06	140.6
5	31.66	116.0		55	8.87	22.27	117.1
10	26.62	98.30	1139	60	8.11	19.89	98.7
15	22.75	74.96	749	65	7.45	17.85	83.7
20	19.67	62.23	567	70	6.88	16.14	71.8
25	17.10	52.06	440.2	75	6.37	14.67	62.2
30	15.10	43.98	340.1	80	5.92	13.39	54.2
35	13.36	37.76	266.2	85	5.52	12.26	47.5
40	11.97	32.61	213.0	90		11.27	41.7
45	10.74	28.58	172.4	95		10.41	37.3

Supersaturated solutions: η in poises ±2% (K. E.) [35]. (The non-sucrose present in crude beet-sugar is equivalent, on the average, to *ca.* 0.97 of its weight of sucrose in solutions of the concentrations below. But a solution of a crude sugar (90% purity) gave a viscosity only 0.8 of that of a pure sucrose solution of the same *density*, 1.314 at 19°C).

Wt. %	η_{20}	η_{30}	Wt. %	η_{20}	η_{30}
60	0.57	0.34	70	4.47	1.97
65	1.35	0.78	75		9.6

$C_{18}H_{32}O_{16}.5H_2O$, Raffinose
(0.1 formal soln. had specific conductance of $<2 \times 10^{-6}$ mhos at 25°C); fused quartz viscometer (K. E.); F/l *in vacuo* [46]

0.00°C		25.00°C		50 00°C	
F/l at 0°	η/η_w	F/l at 25°	η/η_w	F/l at 50°	η/η_w
0.038083	1.06284	0.037973	1.05602	0.037615	1.04723
0.058632	1.10129	0.058466	1.08809	0.057925	1.07780
0.102676	1.18881	0.102297	1.16262	0.129787	1.19272
0.131202	1.25233	0.130727	1.21713	0.174336	1.27057
0.176625	1.36048	0.175818	1.31230		

Systems Containing Two Solutes

$\mathfrak{C}$-Arrangement (*v.* Vol. III, p. viii)

$CH_3OH + C_2H_5OH$, Methyl and Ethyl Alcohols

η in millipoises (K. E.) [5]

$2CH_4O.3H_2O$ / $C_2H_6O.3H_2O$ Volumes...	0 / 100	25 / 75	50 / 50	75 / 25	100 / 0
η_{25}	23.5	21.1	18.8	16.8	14.7
η_{35}	17.2	15.6	14.1	12.8	11.1
η_{45}	13.0	12.0	11.0	10.1	9.2
η_{55}	10.2	9.4	8.8	8.2	7.5

Mixture of 1 volume water with 20 volumes of a mixture of equal volumes of methyl and ethyl alcohols; η in millipoises (K. E.) [5]

t, °C	25	35	45	55
η	9.89	7.97	6.73	5.66

$C_2H_5OH + C_3H_5(OH)_3$, Ethyl Alcohol and Glycerol

N = 1F of glycerol per l of solution [34]

Liquid	η/η_w, 20°
Water	1
50 % alcohol	2.807
N Glycerol in water	1.275
N Glycerol in 50 % alcohol	3.400
N Glycerol in absolute alcohol	1.770

$C_2H_5OH + C_4H_{10}O$, Ethyl Alcohol and Ether

η_{15} [26]; η_{25} [20]

$C_2H_5OH + C_{12}H_{22}O_{11}$, Ethyl Alcohol and Sucrose

η in millipoises [37]

	In 20 Wt. % alcohol		In 50 Wt. % alcohol			
Wt. % sucrose	0	20	0	10	20	30
η_{25}	16.2	29.5	23.2	30.3	45.9	77.0

Dextrose + Acetamide [43]

Sucrose + Dextrose or Levulose

η in millipoises [37]

% sucrose	20	20	20	20	10	5	0
% dextrose	0	5	10	20	20	20	20
η_{25}	16.8	21.0	26.5	47.5	26.0	20.1	16.8
% sucrose	20	20	20	20	10	5	0
% levulose	0	5	10	20	20	20	20
η_{25}	16.8	21.4	26.2	45.2	25.3	19.8	16.2

Mixture containing 8.2 Wt. % each of sucrose, dextrose and levulose had η_{25} = 19.4.

Systems Containing Two Solutes, One an Electrolyte and the Other a Non-Electrolyte

Alphabetical arrangement by non-electrolyte

Acetone + $Ca(NO_3)_2$ [21]

Acetone + CsCl [9]

Acetone + $CsNO_3$ [9]

Acetone + KCNS [23]

Acetone + LiBr [22]

Acetone + RbCl, RbBr, RbI or $RbNO_3$ [7]

Dextrose + HCl, KOH, or Tartaric Acid [43]

Ether + H_2SO_4 [36]

Ethyl Alcohol + $Ca(NO_3)_2$ [32]

Ethyl Alcohol + CsCl or $CsNO_3$ [9]

Ethyl Alcohol + HCl or HBr [16.5]

Ethyl Alcohol + KI [19, 47]

Ethyl Alcohol + KCNS [23]

Ethyl Alcohol + LiBr [22]

Ethyl Alcohol + NaI [16.5, 47]

Ethyl Alcohol + NH_4Br [18]

Ethyl Alcohol + NH_4I [8, 18]

Glycerol + $CoCl_2$ [40]

Glycerol + CsCl or $CsNO_3$ [6]

Glycerol + $CuSO_4$ [29]

Glycerol + KCl [18]

Glycerol + KI [40]

Glycerol + LiBr [40]

Glycerol + $NaNO_3$ [18]

Glycerol + RbBr [8]

Glycerol + RbI [18]

Glycerol + $SrCl_2$ [18]

Methyl Alcohol + CsCl or $CsNO_3$ [9]

Methyl Alcohol + KCNS [23]

Methyl Alcohol + LiBr [22]

Methyl Alcohol + HCl, HBr or NaI [16.5]

Sucrose + LiCl; η in millipoises (K. E.) [17]

Mole ratio, $LiCl/C_{12}H_{22}O_{11}$ =	0	0.05	0.50	5.0
Sucrose, F/l, 25°C	η_{25}	η_{25}	η_{25}	η_{25}
0.2	10.71	10.74	10.92	12.50
0.4	13.08	13.12	13.60	18.27
0.6	16.37	16.51	17.40	28.46
0.8	21.05	21.28	22.93	48.71
1.0	27.84	28.22	31.23	95.8
1.2	38.07	38.71	44.10	231.7
1.4	54.0	55.2	65.3	778
1.6	79.9	82.1	102.6	
1.8	124.8	130.0	172.7	
2.0	218	280	310	

Urea + HCl, KCl or NaOH [14]

Cellulose in Cuprammonium Solutions

η at 20°C of solutions of 20 g of cellulose in 1 l cuprammonium hydroxide solution containing 13 g copper and 200 g ammonia per l may vary between 28 000 poises (by extrapolation) and 0.4 poise according to the extent of degradation (Joyner) [24]. The sliver used in Joyner's work gave η_{20} = 5000 poises after boiling with water.

The Research Department, Woolwich [48] quotes figures of 216 poises for sliver and 74 poises for wood cellulose at 20°C, using a solution containing 11 ± 0.2 g Cu, 205 ± 2 g ammonia, and 20 g cellulose per liter.

Both the above workers confirm the conclusion of Gibson, Spencer and McCall [16] as to the rapid lowering of η on exposure to light or air.

Farrow and Neale [13] find that a carefully bleached cotton cloth should give η_{20} = 10 to 300 poises when dissolved to a 2 % solution in cuprammonium solution containing 15 g Cu and 240 g ammonia per liter.

Effect of Cu Concentration

Two per cent cellulose solutions; η in poises

Cu g/l	10	11.5	13	15	18	24	29.4	NH_3, 210 g/l [24]
η_{20}	266	163	129	101	81	58	53.5	

Cu g/l	9.5	10.4	10.9	11.7	NH_3, 205 g/l [48]
η_{20}	150	137	130	121	

Effect of Concentration of Ammonia.—Joyner [24] finds that with any concentration of copper and with either 1 % or 2 % solutions of various celluloses, increase of ammonia by 10 g/l decreases $\log_{10} \eta$ by 0.047.

Effect of Concentration of Cellulose.—Joyner states that for his solution $\log \eta = \alpha C$, where C = volume concentration and α is a constant for a given cellulose. Farrow and Neale [13], using severely kiered sliver in their cuprammonium solution, find that the equation $(1 + A/C) \log_{10} \eta/\eta_s = B$ represents the results

more accurately, A and B being constants, and η_s, the viscosity of the solvent = 0.015 poise.

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FLUIDITY OF NON-AQUEOUS SOLUTIONS

EUGENE C. BINGHAM

CONTENTS

The A-component key-formula does not begin with 16.

Two-component systems.

Three-component systems.

The A-component has key-formula beginning with 16.

Two-component systems.

Three-component systems.

INTRODUCTION

When the relation between specific volume and volume concentration is a linear one, the fluidity is normally a linear function of the volume concentration. Most of the literature from which the fluidity data are taken contains the corresponding density values, but these have not been reproduced here since such data are very fully given in another volume (*v.* Vol. III, p. 130). The accuracy is very difficult to estimate. Where data of different observers are available the agreement is in many cases not good. Differences of several per cent are not uncommon.

ABBREVIATIONS, SYMBOLS AND UNITS

η_t Viscosity in poises at t, °C

$\varphi_t = \frac{1}{\eta_t}$ Fluidity in rhes (reciprocal poises), at t, °C

MATIÈRES

La formule clé du constituant A ne commence pas par 16.

Systèmes à deux constituants.

Systèmes à trois constituants.

Le constituant A possède une formule clé commençant par 16.

Systèmes à deux constituants.

Systèmes à trois constituants.

INTRODUCTION

Lorsque la relation entre le volume spécifique et la concentration en volume est linéaire, la fluidité est normalement une fonction linéaire de la concentration en volume. La plupart des mémoires dont ont été extraites les données de fluidité contiennent les valeurs des densités correspondantes, mais celles-ci n'ont pas été reproduites ici car de telles valeurs ont déja été données d'une façon complète dans une autre volume (*v.* Vol. III, p. 130). Il est très difficile d'estimer la précision. Lorsque les données d'observateurs différents sont disponibles on constate que l'accord est mauvais dans bien des cas. Des différences de plusieurs pourcent ne sont pas rares.

ABRÉVIATIONS, SYMBOLES ET UNITÉS

η_t Viscosité en poises à t, °C

$\varphi_t = \frac{1}{\eta_t}$ Fluidité en rhes (poises réciproques) à t, °C

INHALTSVERZEICHNIS

Die Schlüsselformel der A-Komponente beginnt nicht mit 16.

Zweikomponenten Systeme.

Dreikomponenten Systeme.

Die A-Komponente hat eine mit 16 beginnende Schlüsselformel.

Zweikomponenten Systeme.

Dreikomponenten Systeme.

EINLEITUNG

Wenn die Beziehung zwischen dem spezifischen Volumen und der Volumkonzentration linear ist, so ist gewöhnlich die Fluidität eine lineare Funktion der Volumkonzentration. Viele der Literaturstellen denen Daten über die Fluidität entnommen worden sind, enthalten die entsprechenden Dichten, welche aber in diesem Abschnitt nicht angegeben werden, da sie sehr vollständig in einem anderen Band (*siehe* Bd. III, S. 130) vorgefunden werden können. Es ist sehr schwer die Genauigkeit abzuschätzen. Wo Daten verschiedener Beobachter vorhanden sind, ist in sehr vielen Fällen die Übereinstimmung nicht gut. Differenzen von mehreren Prozenten sind nicht ungewöhnlich.

ABKÜRZUNGEN, ZEICHEN UND EINHEITEN

η_t Viscosität in Poise, bei t, °C

$\varphi_t = \frac{1}{\eta_t}$ Fluidität in rhes (in reziproken Poise), bei t, °C

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INTRODUZIONE

Quando il volume specifico varia linearmente con la concentrazione in volume, la fluidità e di regola una funzione lineare di questa. La maggior parte della letteratura dalla quale sono stati tratti i dati di fluidità contiene anche i corrispondenti valori di densità; questi però non sono stati riprodotti qui perchè essi sono stati riuniti in un altro volume (*v.* Vol. III, p. 130). È molto difficile valutare la precisione dei dati. La concordanza fra i valori di osservatori diversi in molti casi non è buona. Vi sono spesso differenze di alcuni percenti.

ABBREVIAZIONI, SIMBOLI E UNITÀ

η_t Viscosità in poises a t, °C

$\varphi_t = \frac{1}{\eta_t}$ Fluidità in rhes (poises reciproci) a t, °C

ABBREVIATIONS.—(*Continued*)

g B/l Grams of B in one liter of mixture
M B/l Moles of B in one liter of mixture
M B/l A Moles of B in one liter of A
M B/kg Moles of B in one kilogram of mixture
g B/kg A Grams of B in one kilogram of A
Wt. % B Grams B in 100 g of mixture
M % B Moles B in 100 moles of mixture
Vol. % B Volume of B in 100 volumes of mixture

ARRANGEMENT

The following tables are divided into two sections as shown above in the table of contents. Section I is an A-B Table and follows the Standard Arrangement (*v.* Vol. III, p. viii). Section II is a C-Table and follows the C-arrangement.

ABRÉVIATIONS.—(*Suite*)

g B/l Grammes de B par litre de mélange
M B/l Mol. gr. de B par litre de mélange
M B/l A Mol. gr. de B par litre de A
M B/kg Mol. gr. de B par kilogramme de mélange
g B/kg A Grammes de B par kg de A
Wt. % B Grammes de B dans 100 g de mélange
M % B Mol. gr. de B pour 100 mol. gr. du mélange
Vol. % B Volume de B dans 100 volumes du mélange

ARRANGEMENT

Les tables suivantes sont divisées en deux sections, ainsi qu'il est montré ci-dessus dans la table des matières. La Section I est une Table A-B et elle suit l'arrangement type (*v.* Vol. III, p. viii). La Section II est une Table C et elle suit l'arrangement C.

ABKÜRZUNGEN.—(*Fortsetzung*)

g B/l Gramme von B in 1 Liter der Mischung
M B/l Mole von B in 1 Liter der Mischung
M B/l A Mole von B in 1 Liter von A
M B/kg Mole von B in 1 Kilogramm der Mischung
g B/kg A Gramme von B in 1 Kilogramm von A
Wt. % B Gramme von B in 100 g der Mischung
M % B Mole von B in 100 Molen der Mischung
Vol. % B Volumen von B in 100 Volumteilen der Mischung

ANORDNUNG

Die folgenden Tabellen sind in zwei Abschnitte, entsprechend dem obigen Inhaltsverzeichnis, geteilt. Abschnitt I ist eine A-B Tafel und folgt der Standardanordnung (*siehe* Bd. III, S. viii). Abschnitt II ist eine C-Tafel und folgt der C-Anordnung.

ABBREVIAZIONI.—(*Cont.*)

g B/l Grammi di B in un litro di miscuglio
M B/l Molecole di B in un litro di miscuglio
M B/l A Molecole di B in un litro di A
M B/kg Molecole di B in un chilo di miscuglio
g B/kg A Grammi di B in un chilo di A
Wt. % B Grammi di B in 100 g di miscuglio
M % B Molecole di B in 100 di miscuglio
Vol. % B Volume di B in 100 di miscuglio

ORDINAMENTO

Le tabelle seguenti sono divise in due sezioni, come si è visto sopra, nell'indice. La Sezione I è una Tabella A-B e segue l'ordinamento standard (*v.* Vol. III, p. viii). La Sezione II è una Tabella C e segue l'ordinamento C.

THE A-COMPONENT KEY-FORMULA DOES NOT BEGIN WITH 16

A-B Table, Standard Arrangement (*v.* Vol. III, p. viii)

TWO-COMPONENT SYSTEMS

H_2SO_4

B = HNO_3 (15)

Wt. % B	Vol. % B	φ_{10}	φ_{20}	φ_{40}
0.00	0.00	3.00	4.50	7.90
12.50	14.76	1.55	2.55	5.45
25.00	28.77	1.80	2.85	6.30
37.50	42.11	2.60	3.70	8.35
50.00	58.40	5.40	8.25	15.05
62.50	66.89	7.75	11.55	20.10
75.00	78.45	29.25	37.90	59.20
87.50	89.46	41.40	52.35	75.80
100.00	100.00	96.40	113.9	147.1

NH_3

B = NH_4Br (48)

M B/l	$\varphi_{-33.5}$
0.334	329.8
0.644	300.9
1.10	255.3
1.89	185.8
4.07	68.46

B = $Cu(NO_3)_2.4NH_3$ (48)

0.105	347.2
0.226	313.4
0.362	287.7
0.618	235.5
1.32	127.2

B = AgI (48)

0.202	355.9
0.359	335.6

B = AgI.—(*Continued*)

M B/l	$\varphi_{-33.5}$
0.846	284.8
1.98	195.9
3.38	108.6
7.26	10.12

B = $AgNO_3$ (48)

0.162	349.2
0.276	329.6
0.592	282.7

B = $NaNO_3$ (48)

0.056	367.1
0.107	363.1
0.145	359.7
0.182	356.1
0.246	347.4
0.310	341.3
0.420	328.5
0.528	314.7
0.900	275.7
1.53	224.0
3.30	113.8

B = KI (48)

0.066	372.8
0.110	366.3
0.187	355.8
0.321	348.3
0.545	319.2
1.17	254.3

B = KI.—(*Continued*)

M B/l	$\varphi_{-33.5}$
2.01	189.7
4.31	69.17
0.5	48.06*
1.0	40.40*
2.5	23.43*

* At pressure of saturated vapor.

Bi

B = $BiCl_3$ (3)

M % A	φ_{260}	φ_{270}	φ_{280}
0.0	3.12	3.39	3.70
9.3	2.44	2.70	2.98
18.6			2.13
M % A	φ_{290}	φ_{300}	φ_{310}
0.0	4.00	4.35	4.65
9.3	3.28	3.51	3.85
18.6	2.35	2.63	2.90
30.2		1.64	1.84
M % A	φ_{320}	φ_{330}	φ_{340}
0.00	4.88	5.26	5.56
9.3	4.08	4.26	4.54
18.6	3.12	3.33	3.51
30.2	2.02	2.22	3.51
40.2	1.14	1.29	

Cl_2

B = CCl_4 (98)

Wt. % B	φ_{25}*
97.24	124.8
98.18	120.3
98.92	117.3
100.0	112.6

* At pressure of saturated vapor.

HCl

B = CH_4O, Methyl alcohol (51.5)

B = C_2H_6O, Ethyl alcohol (51.5)

HBr

B = C_2H_6O, Ethyl alcohol (51.5)

I_2

B = CS_2 (117)

g A/l	φ_{25}
0.0	248.7
6.8	248.4
13.6	246.8
27.5	244.7
54.0	243.9
108.0	233.4
214.6	222.0

B = $CHCl_3$ (117)

0.0	168.3
1.5	169.9
2.9	168.4
5.7	168.5
11.5	169.2
22.9	168.8
44.9	167.7

B = C_2H_6O, Ethyl alcohol (117)

0.0	89.8
2.1	89.2
4.2	89.0
8.4	88.6

B = C_2H_6O.—(*Continued*)

g A/l	φ_{25}
16.6	87.8
33.2	86.4
65.9	84.7

B = $C_4H_{10}O$, Ethyl ether (117)

0.0	416.7
6.7	418.4
13.2	413.7
26.2	403.7
52.0	393.8
95.0	373.1
189.7	333.6

B = C_6H_6, Benzene (117)

0.0	165.1
4.1	165.2
7.7	164.8
14.2	164.3
28.4	162.8
56.4	159.8
72.4	154.7

S

B = CS_2 (4)

Wt. % A	φ_{25}
0.0*	282.5
5.35*	261.8
13.12*	235.3
3.61†	268.8
7.92†	256.4
3.25‡, 3.11*	260.4
6.60‡, 6.31*	235.8

* = Rhombic, S_λ.
† = Engel, S_ρ.
‡ = Magnus, S_π.

SO_2

B = CCl_4* (98)

Wt. % B	φ_{25}
0.0	391.3
26.42	352.6
35.79	334.8
48.60	305.1
68.93	239.9
73.28	223.0
85.01	179.0
92.11	149.4
98.870	121.9
99.220	119.7
99.315	118.9
99.672	116.7
100.00	112.7

B = CS_2* (98)

97.41	296.8
98.18	295.7
98.91	293.7
100.00	290.0

B = $CHCl_3$* (98)

97.10	199.1
97.44	197.9
98.12	194.6
100.00	184.4

* At pressure of saturated vapor.

B = CH_4O, Methyl alcohol* (98)

Wt. % B	φ_{25}
0.0	391.3
18.16	320.7
20.27	310.3
25.10	291.2
29.29	281.1
40.89	239.3
51.27	215.5
68.76	191.7
74.47	188.8
91.98	184.4
100.00	183.2

B = C_3H_6O, Acetone (98)

0.00	390.7
12.32	352.1
20.80	331.5
44.90	293.7
47.83	293.3
57.56	288.1
69.40	291.5
73.48	292.9
77.78	297.2
81.98	301.8
94.66	320.3
100.00	328.9

B = $C_4H_{10}O$, Ethyl ether (98)

0.00	390.7
30.46	347.7
50.56	347.2
57.00	356.6
63.71	362.4
66.47	363.2
85.80	409.3
88.30	416.7
91.67	425.0
95.00	434.3
100.00	448.2

B = C_6H_6, Benzene* (98)

0.00	390.7
26.39	329.8
50.44	265.7
52.58	263.3
80.76	203.7
92.62	185.2
95.48	177.6
97.28	174.2
100.00	167.8

B = C_7H_{16}, Heptane* (98)

96.82	268.9
98.29	265.5
100.00	259.4

B = C_7H_8, Toluene* (98)

0.00	390.7
21.43	326.8
27.95	321.9
52.00	256.7
52.92	256.1
71.96	219.4
72.76	217.5
74.72	215.7

* At pressure of saturated vapor.

B = C_7H_8.*—(*Continued*)

Wt. % B	φ_{25}
86.00	204.9
92.52	195.3
96.79	187.3
98.71	183.5
100.00	181.4

B = C_8H_{10}, Xylene* (98)

84.57	187.5
89.08	178.5
91.22	175.6
93.28	171.8
95.00	169.4
96.48	167.6
100.00	165.5

H_2S

B = $CHCl_3$* (98)

99.713	192.1
99.807	190.2
100.00	184.4

* At pressure of saturated vapor.

H_2SO_4

B = $C_2H_4O_2$, Acetic acid (26)

Wt. % B	φ_{15}	$\varphi_{76.5}$
0.00	3.712	19.87
9.93	2.384	13.94
29.88	0.729	9.33
50.18	0.872	10.6
70.07	3.190	25.7
90.01	26.20	79.6
100.00	75.00	177.4

B = $C_2H_6SO_4$, Dimethyl sulfate (26)

Wt. % B	φ_0	$\varphi_{76.5}$
0.00	2.06	18.9
24.98	3.19	24.4
50.15	5.48	35.6
75.02	14.29	66.9
100.00	36.60	124.7

B = $C_4H_{10}O$, Ethyl ether (118)

Wt. % B	φ_{30}
0.0	4.76
2.50	5.30
5.00	6.26
10.00	7.64
15.00	7.86
20.00	7.46
25.00	6.68
30.00	6.28
35.00	6.19
40.00	6.96
45.00	9.09
50.00	13.88
56.436	28.74
60.875	45.58
70.399	101.8
78.221	172.7
83.223	229.4
90.172	322.9
93.370	366.3
100.00	468.6

NH_3

B = CH_4N_2O, Urea (48)

M B/l	$\varphi_{-33.5}$
0.333	356.4
0.376	351.9
0.567	340.2
0.806	319.1
0.966	306.0
2.076	243.0

B = $C_{12}H_{22}O_{11}$, Sucrose (48)

0.022	367.2
0.039	360.0
0.070	345.0
0.124	321.4
0.220	278.0
0.3918	164.3
0.921	44.76

NH_4Br

B = CH_3NO, Formamide (23)

M B/l	φ_{15}	φ_{25}	φ_{35}
0.0	23.2	30.7	39.3
0.1	22.7	30.6	38.0
0.25	22.0	28.9	37.3
0.5	20.9	27.7	36.0

NH_4I

B = CH_3NO, Formamide (23)

M A/l	φ_{15}	φ_{25}	φ_{35}
0.0	23.8	31.2	40.1
0.1	22.9	30.2	38.4
0.25	21.9	29.3	37.5
0.5	19.6	25.9	33.3

NH_4NO_3

B = CH_3NO, Formamide (63)

M A/l	φ_{15}	φ_{25}	φ_{35}
0.0	22.89	30.3	38.0
0.1	22.35	29.5	36.4
0.25	22.00	29.3	36.4
0.5	21.37	28.4	35.4

$SbCl_3$

B = C_3H_6O, Acetone (87, 88)

M % B	φ_{25}	φ_{50}
33.3	5.52	18.83
38	5.96	
50	10.54	24.86
66.6	28.2	52.13
75	50.6	84.53
100	295.0	
M % B	φ_{50}	φ_{80}
0	24.55	46.34
20	17.53	43.80
23	17.50	39.58
25	17.08	41.44
30	17.56	41.51
33.3	18.83	42.37

B = $C_4H_{10}O$, Ethyl ether (87, 88)

M % A	φ_{25}	φ_{32}
0	409.8	429.2
25	99.2	108.2
33.4	51.2	59.6
50	15.3	18.98

$SbCl_3$.—(*Continued*)

B = $C_4H_{10}O$.—(*Continued*)

M % A	φ_{25}	φ_{32}
70	6.53	8.64
75	5.80	7.94
80	5.55	7.49
85	5.91	7.85

B = C_6H_6, Benzene (84, 85)

Wt. % B	φ_{75}
0	42.4
15	44.3
25	48.8
33.4	53.9
50	76.9
66.6	127.2
75	165.0
100	296.7

B = C_6H_7N, Aniline (84, 85)

M % B	φ_{95}	φ_{125}
0.0	138.1	432.9
25.0	16.51	92.42
33.33	6.51	
45.0	2.89	
50.0	2.64	28.05
52.5	2.67	28.00
55.0	2.82	28.22
66.67	5.71	
100.00	65.27	201.2

B = $C_{13}H_{12}$, Diphenylmethane (84, 85)

M % B	φ_{100}
0	65.6
15	50.4
20	49.7
25	49.7
34.87	53.4
50	67.1
100	120.9

B = $C_{19}H_{16}$, Triphenylmethane (84, 85)

0	65.6
33.33	30.85
50	29.5
55	28.9
60	28.5
66.67	29.0
100	31.0

$SbBr_3$

B = C_8H_8O, Acetophenone (84, 85)

M % A	φ_{25}	φ_{50}	φ_{95}
0	61.8	80.3	153.1
25	9.43	17.78	40.34
40	1.64	3.23	19.40
45	1.27	2.62	15.65
48	1.108	2.549	14.93
50	1.036	2.353	14.34
51	1.069	2.439	13.82
52		2.45	13.19
60	1.872	4.44	16.60
70	3.167	7.39	23.26
85		15.80	25.11
100			30.22

B = $C_{13}H_{10}O$, Benzophenone (84, 85)

Wt. % A	φ_{25}	φ_{95}
0.0	7.35	57.3
33.33	0.552	26.8
50.0	0.2086	19.9
55.0	0.1812	
60.0	0.1766	17.7
66.67	0.2118	17.2
70.0		17.4
75.0		17.7
100.0		30.2

$SnCl_4$

B = $C_3H_6O_2$, Ethyl formate (87, 88)

M % B	φ_{30}	φ_{40}	φ_{50}
0	124.1	137.9	149.7
25	65.5	77.4	89.69
50	14.56	20.19	26.65
64	2.27	4.25	7.02
66.5	1.73	3.38	5.97
68	1.91	3.62	6.21
70	3.21	5.25	8.03
75	113.8	15.66	20.39
100	266.7	292.4	321.5

B = $C_4H_8O_2$, Ethyl acetate (87, 88)

M % B	φ_{25}	φ_{50}	φ_{70}
0	108.8	149.7	166.7
30	52.82	80.32	100.8
50	15.50	30.93	47.9
64.1	2.60	9.79	22.8
65.4	2.14	9.16	21.7
66.6	1.99	8.89	21.6
67.4	2.23	9.53	22.8
75	8.51	20.2	36.3
100	226.8	289.9	353

B = $C_4H_8O_2$, Propyl formate (87, 88)

M % B	φ_{50}	φ_{70}
0	149.7	166.7
25	83.1	111.6
50	23.35	39.56
65	6.53	16.13
66.6	6.07	15.25
68	6.67	16.49
75	17.06	30.97
100	253.8	307.7

B = $C_5H_{10}O_2$, Ethyl propionate (80, 81)

M % B	φ_{25}	φ_{70}
0	108.8	166.4
10	90.09	149.9
25	62.62	123.9
40	34.66	89.29
50	18.96	65.92
60	7.47	46.58
65	4.67	44.50
65.20	4.87	46.17
65.87	4.86	47.06
66.67	4.97	48.37
67.11	5.04	48.3
70	7.29	53.0

B = $C_5H_{10}O_2$.—(*Continued*)

M % B	φ_{25}	φ_{70}
75	16.7	66.6
90	95.1	276.2
100	189.0	304.0

B = $C_5H_{10}O_2$, Methyl butyrate (87, 88)

M % B	φ_{25}	φ_{50}	φ_{70}
0	108.8	149.7	166.7
66.5	4.53	20.62	47.8
100	18.32	266.0	320.5

B = C_6H_6, Benzene (87, 88)

M % B	φ_{25}	φ_{70}
0	108.8	166.7
25	140.2	204.5
50	156.7	250.6
75	166.7	266.7
100	164.5	275.5

B = $C_6H_{12}O_2$, Ethyl butyrate (87, 88)

M % B	φ_{25}	φ_{50}	φ_{70}
0	108.8	149.7	166.7
25	52.8	80.3	100.8
50	24.2	34.9	55.8
64	5.32	18.8	41.6
65	5.04	18.7	42.2
66	5.10	18.9	42.5
66.7	5.18	19.1	42.9
67.5	5.50	19.9	44.2
69.2	6.84	22.3	48.1
75	15.56	36.3	66.1
100	159.2	214.6	311.5

B = $C_9H_{10}O_2$, Ethyl benzoate (87, 88)

M % B	φ_{25}	φ_{50}	φ_{70}
0	49.2	78.1	104.7
25	12.6	37.8	64.3
33.4	8.63	31.3	56.6
35	8.49	31.0	56.3
37.5	8.43	30.3	55.7
40	8.44	29.7	53.9
45	9.48	29.9	54.0
50	12.1	32.7	57.4
70	36.8	64.2	91.0
100	108.8	149.9	166.7

$HgCl_2$

B = CH_3NO, Formamide (64)

M A/l	φ_{15}	φ_{25}	φ_{35}
0.0	23.2	31.0	39.8
0.1	22.2	29.6	
0.25	21.3	28.3	

AgI

B = CH_5N, Methylamine (48)

M A/l	φ_0
1.08	293.9
1.24	282.7
2.31	197.0

B = C_2H_7N, Dimethylamine (40)

M A/l	$\varphi_{-33.5}$
0.3195	199.1
0.6375	179.9
1.366	125.1

B = C_2H_7N, Ethylamine (40)

M A/l	$\varphi_{-33.5}$
0.1012	165.4
0.1728	156.9
0.3494	144.5
0.6339	125.1
1.116	100.4

$AgNO_3$

B = CH_5N, Methylamine (48); *cf.* (75)

0.99	221.6
1.29	180.8
1.48	152.6
1.91	111.1
2.76	55.64
3.57	29.78

B = C_2H_3N, Acetonitrile (123)

Wt. % B	φ_{25}
43.07	15.4
68.09	95.6
85.93	190.8
95.20	244.5
100.00	278.6

B = C_2H_7N, Ethylamine (40)

M A/l	$\varphi_{-33.5}$
0.03436	168.2
0.07045	159.5
0.1402	140.8
0.2785	123.9
0.5420	103.1
0.7411	72.78
1.999	14.09

B = C_3H_9N, Propylamine (40)

0.1387	82.1
0.2802	66.7

B = C_5H_5N, Pyridine (121)

Wt. % B	φ_{25}
73.93	17.6
85.12	48.8
90.41	74.3
95.96	90.6
100.00	112.2

B = C_6H_6ClN, *m*-Chloroaniline (121)

M % B	φ_{25}
92.11	10.9
96.91	20.7
98.82	25.5
99.49	27.3
99.81	28.0
99.92	28.4
100.00	28.6

B = C_6H_7N, Aniline (121)

Wt. % B	φ_{25}
89.79	11.16
93.92	16.67
96.98	21.79
98.13	23.47
100.00	27.03

B = C_9H_7N, Quinoline (121)

94.08	14.4
97.19	21.5
98.60	25.4
100.00	29.6

$CoBr_2$

B = CH_3NO, Formamide (64)

M A/l	φ_{15}	φ_{25}	φ_{35}
0.0	23.25	31.05	39.84
0.1	20.44	27.03	34.88

$Ca(NO_3)_2$

B = C_2H_6O, Ethyl alcohol (155)

Wt. % B	φ_{25}
96	5.0
97	12.0
98	26.0
99	51.0
100	92.3

$Sr(NO_3)_2$

B = CH_3NO, Formamide (63)

M A/l	φ_{15}	φ_{25}	φ_{35}
0.0	22.7	30.1	37.8
0.1	20.2	27.1	33.8
0.25	17.4	23.5	29.8

$BaCl_2$

B = CH_3NO, Formamide (23)

M A/l	φ_{15}	φ_{25}	φ_{35}
0.0	23.3	31.1	39.8
0.1	20.2	27.0	34.8

$Ba(NO_3)_2$

B = CH_3NO, Formamide (63)

M A/l	φ_{15}	φ_{25}	φ_{35}
0.0	22.5	30.0	37.7
0.1	20.4	27.1	34.1
0.25	17.2	22.3	29.5

$Ba(CNS)_2$

B = C_2H_7N, Ethylamine (40)

M A/l	$\varphi_{-33.5}$
0.1392	139.0
0.2809	108.3

LiCl

B = CH_5N, Methylamine (48)

M A/l	φ_0
0.355	356.5
0.526	315.8
0.985	232.7
1.35	182.4
2.01	107.0

B = C_2H_6O, Ethyl alcohol (143)

g A/kg B	φ_{15}
0.00	75.9
2.587	71.2
4.824	67.7
10.48	60.9
20.93	50.6
35.01	40.3
45.16	33.4

$LiNO_3$

B = CH_4NO, Formamide (64)

M A/l	φ_{15}	φ_{25}	φ_{35}
0.0	23.4	31.3	40.0
0.15	22.4	31.7	37.8
0.25	21.2	28.0	35.9
0.5	19.3	25.8	33.1

$LiCHO_2$

Formate

B = CH_2O_2, Formic acid (133)

M A/l	φ_{18}
0.000	53.6
0.08513	50.6
0.1292	49.3
0.1810	47.9
0.2703	45.2
0.3441	43.4
0.4335	41.5
M A/l	φ_{25}
0.000	62.3
0.08583	59.0
0.1347	57.2
0.2039	55.0
0.2605	53.2
0.4064	49.1
0.4669	47.5

B = CH_3NO, Formamide (63)

M A/l	φ_{15}	φ_{25}	φ_{35}
0.0	22.7	30.0	37.5
0.15	21.6	28.6	35.8
0.25	19.6	26.4	32.9
0.5	17.6	23.7	29.8

NaBr

B = CH_3NO, Formamide (64)

M A/l	φ_{15}	φ_{25}	φ_{35}
0.0	23.4	31.3	39.8
0.1	22.1	29.3	37.5
0.25	20.5	27.2	35.2
0.5	17.9	24.5	32.0

B = CH_4O, Methyl alcohol (42.5)

NaI

B = CH_3NO, Formamide (64)

M A/l	φ_{15}	φ_{25}	φ_{35}
0.0	23.2	30.3	38.9
0.1	22.1	29.6	37.7
0.25	20.7	27.5	35.7
0.5	18.4	25.0	32.6

B = CH_4O, Methyl alcohol (42.5)

B = C_2H_6O, Ethyl alcohol (155); *cf.* (51.5)

M A/l	φ_{15}	φ_{25}	φ_{35}
0.0	77.4	94.9	114.8
0.125	70.2	84.0	101.9

$NaNO_3$

B = CH_3NO, Formamide (63)

M A/l	φ_{15}	φ_{25}	φ_{35}
0.0	22.7	30.0	37.5
0.1	21.5	28.5	35.9
0.25	19.9	26.8	33.6
0.5	17.9	24.3	31.0

B = CH_5N, Methylamine (48)

M A/l	φ_0
0.226	389
0.387	365
0.575	338
1.075	267

$NaCHO_2$

Formate

B = CH_2O_2, Formic acid (134)

M A/l	φ_0
0.0	53.6
0.06191	51.2
0.08267	50.5
0.1283	49.0
0.2107	46.4
0.3027	43.9
0.4925	38.9
0.5642	37.4
M A/l	φ_{25}
0.04228	59.9
0.06941	58.8
0.1124	57.4
0.2382	52.8
0.4460	46.7
0.5759	43.4
0.7435	39.5
0.9876	34.2

B = CH_3NO, Formamide (63)

M A/l	φ_{15}	φ_{25}	φ_{35}
0.0	22.7	30.0	37.5
0.1	21.4	28.5	35.7
0.25	19.4	26.2	32.9
0.5	17.0	23.3	29.9

$NaC_7H_5O_2$

Benzoate

B = CH_3NO, Formamide (63)

M A/l	φ_{15}	φ_{25}	φ_{35}
0.0	22.7	30.1	37.3
0.1	20.8	27.7	35.0
0.25	18.2	24.7	31.6

$NaC_7H_5O_3$

Salicylate

B = CH_3NO, Formamide (63)

M A/l	φ_{15}	φ_{25}	φ_{35}
0.0	22.8	30.1	37.8
0.1	20.9	28.0	35.0
0.25	18.6	25.1	31.9

$Na_2C_4H_4O_4$

Succinate

B = CH_3NO, Formamide (63)

M A/l	φ_{15}	φ_{25}	φ_{35}
0.0	22.7	30.1	37.3
0.01	19.0	25.6	32.1

$NaC_6H_5SO_3$

Benzenesulfonate

B = CH_3NO, Formamide (63)

M A/l	φ_{15}	φ_{25}	φ_{35}
0.0	22.8	30.15	37.8
0.1	21.2	28.14	35.3

$NaC_7H_3N_2O_6$

1, 3, 5-Dinitrobenzoate

B = CH_3NO, Formamide (63)

M A/l	φ_{15}	φ_{25}	φ_{35}
0.0	22.7	30.1	37.7
0.1	20.2	27.2	33.9

$NaC_7H_6NO_2$

m-Aminobenzoate

B = CH_3NO, Formamide (63)

M A/l	φ_{15}	φ_{25}	φ_{35}
0.0	22.7	30.1	37.7
0.1	20.5	27.2	34.4

Na_2CrO_4

B = CH_3NO, Formamide (64)

M A/l	φ_{15}	φ_{25}
0.0	23.2	31.0
0.1	20.1	27.3

KCl

B = CH_3NO, Formamide (64)

M A/l	φ_{15}	φ_{25}	φ_{35}
0.0	23.2	30.2	39.3
0.1	21.9	29.5	37.8
0.25	21.2	28.0	35.8
0.5	19.0	25.5	33.3

B = CH_4O, Methyl alcohol (42.5)

KBr

B = CH_4O, Methyl alcohol (42.5)

KI

B = CH_4O, Methyl alcohol (143); for more recent data, *cf.* (42.5)

g A/kg B	φ_{15}
5.74	154.7
11.87	152.3
22.65	148.4
45.74	139.5
76.74	130.2
116.94	121.5
g A/kg B	φ_{25} φ_{40}
17.86	173.0 214.6
35.93	166.2 205.6
70.39	155.0 192.0
97.72	147.8 183.7

B = CH_3NO, Formamide (64)

M A/l	φ_{15}	φ_{25}	φ_{35}
0.0	23.2	30.3	38.9
0.1	22.6	29.8	38.0
0.25	21.6	28.4	36.8
0.5	20.1		34.7

B = CH_5N, Methylamine (48)

M A/l	φ_0
1.22	227.7

B = C_2H_6O, Ethyl alcohol (143)

g A/kg B	φ_{15}
4.74	74.5
8.20	73.4
13.37	72.2

KNO_3

B = CH_3NO, Formamide (63)

M A/l	φ_{15}	φ_{25}	φ_{35}
0.0	22.9	30.3	38.0
0.1	21.8	29.0	36.4
0.25	20.7	27.7	35.5
0.5	19.4	25.9	32.9

$KCHO_2$

Formate

B = CH_2O_2, Formic acid (133)

M A/l	φ_{25}
0.0548	59.5
0.0733	58.9
0.1787	55.2
0.1888	54.9
0.2099	54.6
0.2619	53.1
0.2878	52.7
0.3195	51.5
0.3917	49.4
0.4445	48.4
0.6104	44.7

KCNS

B = CH_3NO, Formamide (64)

M A/l	φ_{15}	φ_{25}	φ_{35}
0.0	23.3	30.7	39.1
0.1	22.9	30.5	38.8
0.25	21.8	28.8	36.9
0.5	20.4	27.4	35.2

RbCl

B = CH_3NO, Formamide (64)

M A/l	φ_{15}	φ_{25}	φ_{35}
0.0	23.3	30.7	39.0
0.1	22.3	29.4	38.1
0.25	20.9	27.7	36.0
0.5	19.1	25.8	33.8

RbBr

B = CH_3NO, Formamide (64)

M A/l	φ_{15}	φ_{25}	φ_{35}
0.0	23.2	30.7	39.0
0.1	22.4	29.5	37.8
0.25	21.5	28.6	36.8

RbI

B = CH_3NO, Formamide (64)

M A/l	φ_{15}	φ_{25}	φ_{35}
0.0	23.80	31.18	40.06
0.1	22.56	29.87	37.97
0.25	21.54	28.55	36.54
0.5	20.22	27.66	34.90

$RbNO_3$

B = CH_3NO, Formamide (64)

M A/l	φ_{15}	φ_{25}	φ_{35}
0.0	23.3	30.7	39.0
0.1	22.6	29.9	38.2
0.25	21.8	29.2	37.4

$RbCHO_2$

Formate

B = CH_3NO, Formamide (63)

M A/l	φ_{25}
0.0	30.4
0.1	29.1
0.25	28.1

CsCl

B = CH_3NO, Formamide (23)

M A/l	φ_{15}	φ_{25}	φ_{35}
0.0	23.2	30.8	
0.1	22.3	29.5	37.7
0.25	21.1	28.0	35.9

$CsNO_3$

B = CH_3NO, Formamide (23)

M A/l	φ_{15}	φ_{25}	φ_{35}
0.0	23.2	30.8	
0.1	22.4	29.7	37.9
0.25	21.7	28.8	36.7

Three-Component Systems

Argon

B = O_2

C = N_2 (147, 148)

% A	°K	φ
9.5% B; 89% C		
1.5	77.91	625.4
35% B; 63% C		
2	79.57	595.9
61% B; 36% C		
3	82.34	536.1
96% B; 1% C		
3	89.62	527.6

I_2

B = KI

C = CH_4O, Methyl alcohol (20)

g A/l	g B/l	$\varphi_{25.6}$
126.92	0.00	165.1
112.86	18.44	159.1
111.07	20.75	158.2
108.78	23.74	157.3
105.73	27.73	155.6
101.54	33.20	153.5

NH_4Br

B = CH_4O, Methyl alcohol

C = $C_3H_8O_3$, Glycerol (52)

φ_{25}	φ_{35}	φ_{45}
No solute		
0.0 Wt. % C in (B + C)		
171.2	197.4	223.7
25.0 Wt. % C in (B + C)		
53.0	67.5	83.7
50.0 Wt. % C in (B + C)		
10.4	15.4	22.5
75.0 Wt. % C in (B + C)		
1.61	2.84	4.79
100.0 Wt. % C in (B + C)		
0.165	0.368	0.74
0.1*N* NH_4Br		
0.0 Wt. % C in (B + C)		
159.9	184.8	211.2
25.0 Wt. % C in (B + C)		
48.5	62.1	76.0
50.0 Wt. % C in (B + C)		
10.8	15.9	22.9
75.0 Wt. % C in (B + C)		
1.67	2.99	4.97
100.0 Wt. % C in (B + C)		
0.165	0.368	0.74

B = C_2H_6O, Ethyl alcohol

C = $C_3H_8O_3$, Glycerol (52)

φ_{25}	φ_{35}	φ_{45}
No solute		
0.0 Wt. % C in (B + C)		
93.7	115.2	137.7
25.0 Wt. % C in (B + C)		
23.9	32.8	43.4
50.0 Wt. % C in (B + C)		
4.71	7.40	11.5
75.0 Wt. % C in (B + C)		
0.972	1.83	3.22
100.0 Wt. % C in (B + C)		
0.165	0.368	0.740
0.1*N* NH_4Br		
0.0 Wt. % C in (B + C)		
86.1	105.1	125.3
25.0 Wt. % C in (B + C)		
22.7	31.0	40.9
50.0 Wt. % C in (B + C)		
4.73	7.55	11.54
75.0 Wt. % C in (B + C)		
0.92	1.73	3.04
100.0 Wt. % C in (B + C)		
0.155	0.349	0.714

$Cu(NO_3)_2$

B = C_2H_6O, Ethyl alcohol

C = C_3H_6O, Acetone (61)

Wt.*	φ_0	φ_{25}
No solute		
0	53.9	90.4
25	96.1	148.9
50	147.0	205.2
75	200.4	264.8
100	244.1	308.9
0.2*N* $Cu(NO_3)_2$		
Wt.*	φ_{25}	
0	72.8	
25	118.4	
50	170.6	
75	223.0	
100	263.5	

* Wt. = Wt. % C in (B + C).

$AgNO_3$

B = C_2H_3N, Acetonitrile

C = C_5H_5N, Pyridine (123)

Solvent = 1 Vol. B + 2 Vol. C

Wt. % A in solv.	φ_{25}
0.00	172.1
5.05	146.2
9.17	120.3
16.41	78.7
29.04	33.3

B = C_5H_5N, Pyridine

C = C_6H_7N, Aniline (121)

Solvent = 1 Vol. B + 1 Vol. C

Wt. % A in solv.	φ_{25}
0.00	53.8
4.063	40.7
10.67	24.6
17.74	12.22
29.40	25.9

B = C_5H_5N; C = C_6H_7N.—(*Continued*)

Solvent = 1 Vol. B + 4 Vol. C

Wt. % A in solv.	φ_{25}
0.00	36.6
3.72	28.0
7.31	21.0
18.29	6.96

$CoCl_2$

B = CH_4O, Methyl alcohol

C = $C_3H_8O_3$, Glycerol (135)

Vol. % C in (B + C)	φ_{25}	φ_{35}
Pure solvents (B + C)		
0.0	176.9	204.6
25.0	51.0	65.0
50.0	10.8	15.7
75.0	1.65	2.82
100.0	0.158	0.340
(B + C) + 0.1*N* $CoCl_2$		
0.0	157.1	181.6
25.0	44.5	57.6
50.0	9.26	13.4
75.0	1.35	2.40
100.0	0.133	0.297

B = C_2H_6O, Ethyl alcohol

C = $C_3H_8O_3$, Glycerol (135)

Pure solvents (B + C)		
10	90.1	110.3
25	22.9	31.4
50	4.87	7.56
75	0.92	1.68
100	0.158	0.340
(B + C) + 0.1*N* $CoCl_2$		
10	83.8	101.8
25	20.3	27.7
50	4.08	6.38
75	0.739	1.355
100	0.133	0.297

$Ca(NO_3)_2$

B = CH_3NO, Formamide

C = C_2H_6O, Ethyl alcohol (63)

Wt. % C in (B + C)	φ_{15}	φ_{25}	φ_{35}
0M A/l			
25	29.66	38.60	48.22
50	40.40	51.71	63.82
0.1M A/l			
25	26.75	35.28	43.90
50	36.05	46.34	56.98

B = CH_4O, Methyl alcohol

C = C_3H_6O, Acetone (61)

Wt. % C in (B + C)	φ_0	φ_{25}
Pure solvents (B + C)		
0.0	122.2	176.7
25.0	153.9	216.7
50.0	187.4	257.0
75.0	222.2	290.1
100.0	244.1	308.9

B = CH_4O; C = C_3H_6O.— (*Continued*)

Wt. % C in (B + C)	(B+C)+ 0.1*N* $Ca(NO_3)_2$	(B+C)+ 0.00016*N* $Ca(NO_3)_2$
	φ_{25}	
0.0	161.8	180.4
25.0	188.0	217.2
50.0	220.6	254.7
75.0	255.6	287.3
100.0	282.1	307.3

LiBr

B = CH_4O, Methyl alcohol
C = C_3H_6O, Acetone (67)

Wt. % C in (B + C)	φ_0	φ_{25}
	0M A/l	
0	122.20	176.70
25	153.90	216.70
50	187.40	257.10
75	222.20	290.10
100	244.10	308.90
	0.000625M A/l	
0	119.82	177.46
25		197.29
50	173.17	236.18
75		279.25
100	242.85	299.42
	0.1M A/l	
0	111.18	163.28
25		183.30
50		220.87
75		264.88
100	232.45	286.96

C = $C_3H_8O_3$, Glycerol (135)

Vol. % C in (B + C)	φ_{25}	φ_{35}
For pure solvents, *v.* A = $CoCl_2$ (B + C) + 0.1*N* LiBr		
0.0	164.0	188.5
25.0	47.5	60.7
50.0	9.88	14.4
75.0	1.53	2.63
100.0	0.147	0.313

B = C_2H_6O, Ethyl alcohol
C = C_3H_6O, Acetone (67)

Wt. % C in (B + C)	φ_0	φ_{25}
	0M A/l	
0	53.9	90.4
25	96.1	148.9
50	147.0	205.2
75	200.4	264.8
100	244.1	308.9
	0.000625M A/l	
0	45.48	81.69
25		129.34
50		193.59
75		258.10
100	242.85	299.42

B = C_2H_6O; C = C_3H_6O.— (*Continued*)

Wt. % C in (B + C)	φ_0	φ_{25}
	0.1M A/l	
0	40.96	73.18
25		121.69
50	136.0	180.05
75		235.99
100	232.45	286.96

C = $C_3H_8O_3$, Glycerol (135)

Vol. % C in (B + C)	φ_{25}	φ_{35}
For pure solvents, *v.* A = $CoCl_2$ (B + C) + 0.1*N* LiBr		
10	80.9	101.4
25	21.9	30.3
50	4.52	7.08
75	0.838	1.549
100	0.147	0.313

$LiNO_3$

B = CH_3NO, Formamide
C = C_2H_6O, Ethyl alcohol (63)

Wt. % C in (B + C)	φ_{15}	φ_{25}	φ_{35}
	0M A/l		
25	29.65	38.82	47.87
50	40.45	51.76	63.49
75	56.98	70.87	85.32
	0.1M A/l		
25	28.39	36.89	46.10
50	38.12	48.01	59.74
75	52.77	65.70	79.37
	0.25M A/l		
25	26.32	34.73	43.25
50	34.95	45.07	55.28
75	47.10	59.52	71.58

KI

B = CH_4O, Methyl alcohol
C = $C_3H_8O_3$, Glycerol (135)

Vol. % C in (B + C)	φ_{25}	φ_{35}
For pure solvents, *v.* A = $CoCl_2$ (B + C) + 0.1*N* KI		
0.0	168.3	194.2
25.0	49.5	63.0
50.0	10.7	15.5
75.0	1.59	2.75
100.0	0.149	0.319

B = C_2H_6O, Ethyl alcohol
C = $C_3H_8O_3$, Glycerol (135)

For pure solvents, *v.* A = $CoCl_2$ (B + C) + 0.1*N* KI		
10	85.0	104.2
25	22.1	30.4
50	4.86	7.54
75	0.909	1.66
100	0.149	0.319

KCNS

B = CH_4O, Methyl alcohol
C = C_2H_6O, Ethyl alcohol (68)

Wt. %*	φ_0	φ_{25}
	0M A/l	
0	110.7	165.4
25	99.7	147.3
50	79.4	124.9
75	61.8	105.5
100	47.4	87.4
	0.1M A/l	
0	104.2	157.4
25	94.5	140.6
50	74.6	120.9
75	58.6	101.1
100	44.7	79.3

C = C_3H_6O, Acetone (68)

	0M A/l	
0	110.7	165.4
25	153.9	196.6
50	193.1	222.3
75	230.5	240.6
100	198.2	251.5
	0.1M A/l	
0	104.2	157.4
25	134.6	185.9
50	177.6	202.7
75	211.6	219.0
100	188.9	242.4

B = C_2H_6O, Ethyl alcohol
C = C_3H_6O, Acetone (68)

	0M A/l	
0	47.4	87.4
25	86.5	136.4
50	141.2	187.5

B = C_2H_6O; C = C_3H_6O.— (*Continued*)

Wt. %*	φ_0	φ_{25}
	0M A/l	
75	204.1	227.6
100	198.2	251.5
	0.000625M A/l	
0		83.5
25		131.3
50		186.0
75		224.5
100		249.4
	0.1M A/l	
0	44.7	79.3
25	76.8	128.1
50	126.0	165.9
75	186.8	214.4
100	188.9	242.4

RbI

B = CH_3NO, Formamide
C = C_2H_6O, Ethyl alcohol (63)

Wt. %*	φ_{15}	φ_{25}	φ_{35}
	0M A/l		
25	29.7	38.9	48.3
50	40.5	51.7	63.4
75	56.9	70.7	84.9
	0.1M A/l		
25	28.8	37.6	46.6
50	38.9	49.2	60.7
75	52.7	67.4	81.4
	0.25M A/l		
50	35.8	45.7	56.5
75	50.1	63.3	76.4

* Wt. % = Wt. % C in (B + C).

THE A-COMPONENT HAS KEY-FORMULA BEGINNING WITH 16

℃-Table, the ℃-Arrangement (*v.* Vol. III, p. viii)

TWO-COMPONENT SYSTEMS

CCl_4

B = $CHCl_3$ (99, 102)

50 Wt. % A

°C	φ
0	116.8
25	153.8
40	183.5
55	206.6

(99)

Wt. % A	φ_{25}
0.00	185.2
19.27	175.7
57.28	151.7
81.17	131.4
100.00	113.2

B = C_2Cl_4
Tetrachloroethylene (58)

0.0	107.6
20.3	113.2
33.6	120.4
50.3	122.4
67.0	123.5
80.1	122.5
100.0	119.2

B = $C_2H_2Cl_4$, 1, 1, 2, 2-Tetrachloroethane (58)

Wt. % A	φ_{25}
0.0	107.6
20.0	101.5
33.33	98.3
50	90.4
66.67	82.0
80	72.8
100	61.9

B = C_2H_5I; for data at 25, 35, and 50°C, *v.* (157)

B = C_2H_6O, Ethyl alcohol (46)*

Wt. % B	°C	φ
0.0	75.6	200.4
4.58	65.1	193.1
6.71	64.5	191.9
9.65	64.0	192.3
20.96	63.8	188.7
30.2	64.2	188.7
36.6	64.8	190.1

* Paper also contains density data

CCl_4.—(*Continued*)

B = C_2H_6O.—(*Continued*)

Wt. % B	°C	φ
58.8	67.7	196.1
73.0	70.5	204.1
100.0	77.1	226.2

B = C_3H_6O, Acetone (124, 125)

M % B	φ_0
0.00	75.2
11.40	87.8
36.44	117.4
51.18	136.2
73.55	177.9
86.53	210.1
96.67	237.5
100.00	250.0

M % B	φ_0	φ_{20}	φ_{40}
(145)			
0.0	138	173	204
17.6	137	171	205
39.1	145	183	218
51.7	154	196	235
63.8	176	215	254
84.3	204	258	301
100.0	247	293	355

M % B	φ_{-13} (43)	φ_0 (43)
0	117	140
10	112	135
20	110	134
30	109	138
60	123	166
100	222	253

See also (157) for data at 18, 30 and 40°C

Wt. % B	°C (46)*	φ
0.00	60.2	256.5
6.79	62.0	263.2
12.20	62.8	272.5
27.4	63.0	296.7
36.1	62.1	312.5
53.5	60.0	346.0
59.6	59.2	355.9
68.7	58.2	375.9
80.4	57.1	387.6
100.0	55.4	420.2

* Paper also contains density data.

B = $C_4H_8O_2$, Ethyl acetate; for data at 15, 35, and 50°C, *v.* (157).

B = C_6H_6, Benzene (102)

50 Wt. % B

°C	φ
0	97.1
25	144.2
40	181.8
55	212.8

Wt. % B	°C (46)*	φ
0.0	75.4	201.2
10.9	75.5	216.9
22.8	75.8	234.7
46.1	76.4	259.1
53.8	76.7	266.7
73.4	77.6	289.0
100.0	79.3	315.5

* Paper also contains density data.

B = C_6H_6.—(*Continued*)

Wt. % B	φ_{25} (99)
0.00	113.2
13.73	123.8
40.78	141.6
58.60	151.5
100.00	166.9

(141)

Wt. % B	φ_0	φ_{10}	φ_{20}
0.00	74.1	88.2	103.2
22.37	83.6	100.0	117.6
43.79	91.9	110.1	128.9
67.71	100.6	120.2	141.4
100.00	110.8	131.5	154.1
Wt. % B	φ_{30}	φ_{40}	φ_{50}
0.00	118.9	135.1	153.0
22.37	136.2	156.0	176.7
43.79	149.0	171.5	194.9
67.71	163.4	186.6	211.4
100.00	178.0	203.1	228.8
Wt. % B	φ_{60}		φ_{70}
0.00	171.5		191.0
22.37	198.8		
43.79	219.3		243.3
67.71	237.0		263.9
100.00	256.1		284.9

B = $C_{10}H_8$, Naphthalene; for data from 15 to 31°C, *v.* (74.1).

CS_2

B = CH_3I (141)

Wt. % A	φ_0	φ_{10}	φ_{20}
0.00	168.3	186.6	205.3
21.60	193.1	211.4	230.9
38.81	207.5	225.7	243.9
48.11	213.2		248.1
68.81	222.7	242.1	261.8
82.39	228.3	248.1	268.1
100.00	232.8	253.0	272.5
Wt. % A	φ_{30}		φ_{40}
0.00	224.8		244.7
21.60	250.6		271.0
38.81	263.2		282.5
48.11	267.4		285.7
68.81	280.1		299.4
82.39	288.2		309.6
100.00	293.5		314.0

B = C_2H_6O, Ethyl alcohol (27)

Wt. % B	φ_{25}
0.00	273.5
18.07	203.0
26.50	182.9
30.05	176.3
47.18	150.2
60.50	131.2
67.69	118.9
74.36	110.3
80.71	104.9
83.09	105.8
100.00	89.8

B = C_3H_6O, Acetone (43); *v. also* (157)

M % B	φ_{-13}	φ_{-10}	φ_0
0	194.6	202.0	227.3
40	218.8	226.2	247.5
60	222.2	241.5	253.8
80	216.9	228.3	254.5
100	206.6	222.2	250.0
M % B	φ_{15}		φ_{35}
0	261.1		301.2
40	277.8		328.9
60	285.7		339.0
80	292.4		348.4
100	299.4		359.7

B = $C_4H_8O_2$, Ethyl acetate (99)

Wt. % B	φ_{25}
0.00	279.3
16.40	272.5
39.25	257.1
66.41	240.4
100.00	216.5

B = $C_4H_{10}O$, Ethyl ether (99)

0.00	279.3
13.10	295.9
34.37	326.8
62.76	371.7
100.00	434.8

B = C_6H_6, Benzene (99)

0.00	279.3
8.87	266.0
34.86	224.2
75.89	183.8
100.00	166.9

B = C_7H_8, Toluene (99)

0.00	279.3
7.27	270.3
39.99	239.8
63.24	213.2
100.00	184.8

$CHBr_3$

B = CH_4O, Methyl alcohol (111)

M A/l	φ_{20}
0.25	162
0.5	156
1.0	143

B = C_2H_6O, Ethyl alcohol (110)

0.25	79.84
0.5	77.10
1.0	75.87

B = C_3H_6O, Acetone (111)

0.25	286.6
1.0	246.0

B = C_3H_8O, Propyl alcohol (111)

1.0	44.2

B = $C_4H_{10}O$, Ethyl ether (111)

1.0	290.7

B = $C_5H_{12}O$, Isoamyl alcohol (111)

M A/l	φ_{20}
1.0	24.59

B = $C_6H_5NO_2$, Nitrobenzene (26)

Wt. % B	φ_{10}	$\varphi_{76.5}$
0.00	45.1	99.1
9.68	44.4	103.7
25.85	42.3	106.2
50.08	40.3	110.6
65.83	40.3	113.5
88.39	41.0	117.0
100.00	41.5	117.3

B = C_6H_6, Benzene (111)

M A/l	φ_{20}
1.0	135.4

$CHCl_3$

B = C_2H_6O, Ethyl alcohol (52)

Wt. % B	°C	φ
0.0	60.2	250.6
5.78	58.5	250.0
10.05	58.4	247.5
10.91	58.5	246.3
24.02	59.8	227.3
35.28	61.5	224.2
44.7	63.5	216.5
56.1	66.4	213.7
68.8	69.8	214.1
83.6	73.4	218.8
100.0	77.1	226.2

M A/l	φ_{20} (46, 110)
0.25	102.3
0.5	102.6
1.0	105.4

B = C_3H_6O, Acetone (157)

B = $C_4H_{10}O$, Ethyl ether (141)

Wt. % B	φ_0	φ_{10}
0.00	142.9	159.8
15.94	147.5	168.1
40.14	177.9	204.5
59.80	227.2	257.7
79.30	285.7	320.5
100.00	349.6	387.2
Wt. % B	φ_{20}	φ_{30}
0.00	177.1	195.7
15.94	189.4	211.9
40.14	232.6	261.8
59.80	289.0	322.6
79.30	355.9	393.7
100.00	426.5	471.7

B = $C_4H_{12}ClN$, Diethylammonium chloride (150)

M B/l	φ_{25}
0.0	171.8
0.1	165.3
0.4	149.7

B = $C_4H_{12}N_2O_3$, Diethylammonium nitrate (150, 151)

0.4	142.4

B = C_6H_5Br, Bromobenzene (124, 125)

M % B	φ_0
0.00	142.9
8.48	133.0
23.54	116.6
40.17	98.5
64.69	83.5
86.86	72.5
100.00	68.0

B = C_6H_6, Benzene (99)

Wt. % B	φ_{25}
0.00	185.2
6.97	183.2
23.01	179.5
72.78	172.1
85.83	170.4
100.00	166.9

50 Wt. % B (102)

°C	φ
0	127.2
25	176.2
40	210.5
55	241.8
70	275.9

B = C_6H_{12}, Cyclohexane; for data at 20°C, *v.* (152.2).

B = $C_6H_{16}ClN$, Triethylammonium chloride (150)

M B/l	φ_{25}
0.1	163.4
0.2	159.2

B = C_8H_8O, Acetophenone (126)

M % B	φ_{25}
0.00	181.8
9.92	152.7
33.70	109.3
50.10	90.3
71.25	74.0
88.75	65.4
100.00	60.8

B = $C_8H_{10}O$, Phenetole (126)

M % B	φ_0
0.00	142.9
9.09	123.8
32.38	96.2
48.18	84.5
80.09	62.4
100.00	53.1

B = $C_8H_{20}BrN$, Tetraethylammonium bromide (151)

Wt. % B	φ_{25}
0.00	173.6
6.12	101.8
7.08	92.4

B = $C_8H_{20}ClN$, Tetraethylammonium chloride (150, 151)
φ_{25} = 159.7 for M B/l = 0.1.

B = $C_{10}H_8$, Naphthalene; for data from 6 to 20°C, *v.* (74.1).

B = $C_{10}H_{12}$, Tetrahydronaphthalene; for data at 20°C, *v.* (152.2).

B = $C_{10}H_{12}O$, Anethole; for data at 20°C, *v.* (152.2).

B = $C_{10}H_{24}ClN$, Diisoamylammonium chloride (150, 151)
φ_{25} = 160.0 for M B/l = 0.2.

B = $C_{12}H_{10}O$, Phenyl ether (124, 125)

M % B	φ_{25}
0.00	185.9
18.30	120.5
43.04	71.9
68.64	45.0
100.00	27.3

B = $C_{16}H_{20}N_2O$, Camphorquinone α- (β-)phenylhydrazone (137)

M B/kg	$\varphi_{24.7}$
0.25	157.9 (β)
0.25	150.7 (α)

CH_2Cl_2
Methylene chloride

B = C_3H_6O, Acetone (126)

M % B	φ_0
0.00	184.2
12.76	186.9
42.35	198.4
60.46	210.5
81.12	226.2
92.27	239.2
100.00	250.0

CH_2O_2
Formic acid

B = CH_3NO, Formamide (103)

M % B	φ_{25}	φ_{40}
0.00	62.5	83.3
10.00	51.4	70.0
20.05	43.2	59.3
30.15	39.1	54.1
40.00	35.1	48.4
50.02	32.7	44.8
60.01	31.3	43.3
70.00	30.4	42.7
80.01	30.2	42.5
90.00	29.9	42.2
100.00	29.8	42.0

B = CH_5NO_2, Ammonium formate (134)

M B/l	φ_{25}
0.00	61.7
0.05978	59.5
0.1422	57.3
0.2868	53.8
0.3207	53.0
0.3676	52.0
0.5221	48.5
0.8290	42.5
0.8847	41.3

B = $C_2H_4O_2$, Acetic acid (21)

Wt. % B	φ_{15}	φ_{25}
0	50.9	63.6
10	50.8	63.2
20	50.0	62.2
30	49.7	62.2
40	50.4	63.0
50	51.5	63.9
60	53.1	66.4
70	55.8	68.4
80	58.8	71.9
90	64.2	77.8
100	70.9	85.2

Wt. % B	φ_{11} (55)
0.0	46.8
22.7	44.8
50.0	43.5
68.7	41.9
100.0	39.6

B = $C_7H_9NO_2$, Aniline formate (134)

M B/l	φ_{25}
0.08122	58.7
0.1587	56.3
0.3316	51.5
0.4070	50.0
0.6276	44.8
1.0410	36.5

CH_3NO
Formamide

B = CH_5NO_2, Ammonium formate (63)

M B/l	φ_{15}	φ_{25}	φ_{35}
0.0	22.8	30.0	37.9
0.1	22.2	29.4	36.8
0.25	21.1	28.2	35.4

B = $C_2H_4O_2$, Acetic acid (103)

M % B	φ_{25}	φ_{40}
0.0	29.8	42.0
9.62	26.1	38.6
20.39	24.1	34.5
29.74	23.2	34.4
40.56	23.0	34.4
49.82	23.7	35.8
59.89	25.9	38.6
69.42	28.7	42.3
78.95	35.0	49.3
89.10	50.0	68.4
100.00	78.1	101.3

B = C_2H_6O, Ethyl alcohol (103)

M % B	φ_{25}	φ_{40}
0.00	29.8	42.0
10.00	32.7	46.0
18.92	35.9	50.3
29.76	39.8	55.6
39.29	44.3	61.6
50.09	49.7	68.3
59.29	55.1	75.8
69.86	64.0	87.3
80.09	72.7	98.4
89.95	81.4	109.2
100.00	92.1	121.8

v. also p. 31, A = $LiNO_3$

B = $C_3H_6O_2$, Propionic acid (103)

M % B	φ_{25}	φ_{40}
0.0	29.8	42.0
2.40	26.1	28.2
8.99	17.9	22.3
18.85	14.4	
26.62	13.9	21.2
40.13	14.3	22.1
50.24	15.4	24.0
60.21	17.6	28.2
70.08	22.5	34.8
80.51	29.7	44.8
89.98	46.5	65.8
100.00	96.6	118.6

B = C_3H_8O, Propyl alcohol (42)

Wt. % B	φ_{25}
0.00	30.3
11.23	30.6
20.67	30.9
29.94	32.0
39.96	33.5
49.99	35.8
59.99	38.1
69.99	41.7
79.97	45.0
90.03	50.3
94.55	51.7
100.00	51.9

B = $C_4H_8O_2$, *n*-Butyric acid (103)

M % B	φ_{25}	φ_{40}
0.00	29.8	42.0
4.90	20.0	30.7
14.30	13.6	20.9
20.10	11.7	18.0
29.89	10.9	17.2
40.04	10.7	17.2
49.73	11.9	18.6
59.69	14.1	22.4
69.87	19.1	28.9
79.56	28.3	39.0
89.57	42.9	57.7
100.00	64.3	81.5

B = $C_4H_{10}O$, Isobutyl alcohol (42)

Wt. % B	φ_{25}
10.09	28.7
19.95	27.1
30.00	26.6
39.81	25.9
49.98	26.2
59.88	27.1
69.84	28.4
80.02	30.2
89.96	31.8
95.00	31.9
100.00	29.7

B = $C_4H_{12}ClN$, Tetramethylammonium chloride (23, 64)

M B/l	φ_{15}	φ_{25}	φ_{35}
0.0	23.4	31.3	39.8
0.1	22.8	30.2	38.4
0.25	22.2	29.2	37.3
0.5	20.9	28.0	35.8

CH_3NO.—(*Continued*)

B = C_5H_5N, Pyridine (33)

Wt. % B	φ_{25}
82.88	73.3
88.90	86.2
92.23	94.0

B = $C_5H_{12}O$, Isoamyl alcohol (26)

Wt. % B	φ_0	$\varphi_{76.5}$
0.00	13.24	79.7
10.38	11.66	77.4
30.14	9.40	75.7
49.84	9.00	76.3
69.92	10.08	84.9
90.01	11.96	99.5
97.18	11.79	103.5
100.00	11.32	105.2

Wt. % B (42)	φ_{25}
10.01	28.03
19.94	26.32
29.98	24.56
39.95	23.52
50.01	23.40
60.00	23.96
69.98	25.04
79.95	26.33
84.92	27.11
89.86	28.00
95.01	27.94
100.00	26.33

B = $C_8H_{20}NI$, Tetraethylammonium iodide (23, 64)

M B/l	φ_{15}	φ_{25}	φ_{35}
0.0	23.3	30.7	39.0
0.1	22.6	30.0	38.4
0.25	21.9	28.7	37.2
0.5	20.5	27.6	35.7

CH_4N_2O

Urea

B = CH_4O, Methyl alcohol (143)

g A/kg B	φ_{25}	φ_{40}
0.0	181.1	224.2
8.693	176.5	219.4
15.67	173.3	214.5
29.86	167.6	207.5
43.35	161.7	201.5
61.10	155.4	194.0
91.54	149.5	182.1

B = CH_5N, Methylamine (48)

M A/l	φ_0
0.93	326.2
1.75	253.2
3.33	156.8

B = C_2H_6O, Ethyl alcohol (143); *cf.* (51.5)

M % B	φ_{25}	φ_{50}
95.465	80.5	128.8
96.934	83.7	132.7
98.588	87.7	137.0
99.266	89.2	139.6
100.000	91.1	142.1

C_2H_6O.—(*Continued*)

M % B	φ_{40}
95.352	104.2
96.335	107.2
97.083	109.6
98.197	113.1
98.917	115.6
99.339	117.1
99.630	118.6
100.000	119.3

B = C_5H_5N, Pyridine (33)

Wt. % B	φ_{25}
99.09	106.5

CH_4N_2S

Thiourea

B = C_5H_5N, Pyridine (33)

87.43	49.5
94.48	79.9

CH_4O

Methyl alcohol

B = C_2H_5I, Ethyl iodide (145)

Wt. % B	φ_{20}
0.0	167.4
31.3	164.8
73.2	158.2
100.0	154.8

For data at 20, 35, and 45°C, *v.* (157).

B = C_2H_6O, Ethyl alcohol (55)

Wt. % B	φ_{25}
0.00	177.9
8.75	170.6
15.23	165.3
19.31	161.9
58.98	126.8
89.6	101.6
95.63	95.5
100.00	91.6

Wt. % B (16)	Vol. % B, 25°C	φ_{25}	φ_{35}
0.00	0.0	182.4	209.9
26.16	26.23	156.6	181.1
49.60	49.78	135.6	157.4
73.85	74.15	113.6	134.0
100.00	100.0	91.0	109.1

Wt. % B	φ_{45}	φ_{55}	φ_{65}
0.00	238.0	269.5	
26.16	207.9	236.3	
49.60	182.4	210.1	241.2
73.85	157.3	183.2	
100.00	130.6	155.0	181.5

v. also p. 31, A = KCNS

B = C_3H_6O, Acetone (61, 66)

Vol. % B	φ_0	φ_{25}
0	116.7	171.6
25	136.2	193.2
50	167.8	231.0
75	212.3	270.1
100	233.2	288.9

v. also p. 31, A = LiBr

B = C_3H_8O, Propyl alcohol (55)

Wt. % B	φ_{25}
0.0	177.9
11.1	164.5
23.8	140.9
65.2	93.1
91.8	61.1
93.75	56.4
96.6	54.2
100.0	52.2

B = $C_3H_8O_3$, Glycerol *v.* p. 30, A = NH_4Br *and* A = $CoCl_2$.

B = $C_4H_4O_4$, Acetylenedicarboxylic acid (60)

3.70	165.5
7.20	148.1

B = $C_4H_4O_4$, Fumaric acid (60); *cf.* (137)

3.35	166.0
8.15	143.1

B = $C_4H_4O_4$, Maleic acid (137)

B = $C_4H_6O_4$, Succinic acid (60)

Wt. % B	φ_{25}
0.00	181.5
3.62	165.9
5.96	152.3
10.08	135.6

B = $C_4H_{10}O$, Ethyl ether (5)

0.00	181.6
23.12	211.2
35.07	232.7
47.40	260.0
60.23	296.0
73.08	338.6
86.33	391.7
100.00	442.5

φ_{25} = 260.1 at 50 Vol. % B (6).

B = $C_5H_6O_4$, Citraconic acid (137)

B = $C_5H_6O_4$, Mesaconic acid (137)

B = $C_6H_5NO_2$, Nitrobenzene (47)

Vol. % B	φ_{25}
0	178.3
25	147.8
50	116.7
75	87.3
100	55.2

B = C_6H_6, Benzene

Vol. % B	φ_{25} (17)	φ_{25} (48)
0	178.4	178.4
25	177.3	177.2
50	176.0	176.0
75	174.7	174.7
100	173.7	173.7

Wt. % B	°C (46)*	φ
0.00	63.7	306.7
18.14	59.9	288.2
31.60	58.2	282.5
41.60	57.6	278.6

C_6H_6.—(*Continued*)

Wt. % B	°C (46)*	φ
50.1	57.4	278.6
63.3	57.2	277.0
70.4	57.3	277.8
78.5	57.6	276.2
90.4	59.0	276.2
91.9	59.6	278.6
100.0	79.3	315.5

* Paper also contains density data.

B = C_7H_8O, Anisole (5)

Vol. % B	φ_{25}
50	141.8 (6)

Wt. % B	φ_{25}
0.00	180.5
15.11	170.5
29.40	160.6
42.91	151.0
55.60	141.4
67.62	130.5
79.00	123.5
89.73	112.9
100.00	99.0

B = $C_8H_{10}O$, Phenetole (5)

0.00	180.6
14.83	167.9
28.93	156.1
42.24	143.8
54.88	132.1
67.00	122.6
78.57	111.9
100.00	87.6

B = $C_9H_6O_2$, Phenylpropiolic acid (60)

5.21	163.5
10.35	147.3

B = $C_9H_8O_2$, Cinnamic acid (60)

6.25	157.8
9.24	151.0
11.06	143.7

B = $C_9H_{10}O_2$, β-Phenylpropionic acid (60)

4.66	167.5
9.32	151.8

B = $C_{10}H_8O$, α-Naphthol; for data at 20°C, *v.* (152.2).

B = $C_{10}H_{12}$, 1,2,3,4-Tetrahydronaphthalene (59)

0.00	178.3
5.10	170.7
14.15	160.6
23.79	148.9
(50.6)	110.4

B = $C_{14}H_{10}O_2$, Benzil (143)

g B/kg A	φ_{15}
0.00	158.9
10.94	156.0
18.89	154.3
31.12	151.8
42.93	150.1

B = $C_{14}H_{10}O_2$.—(*Continued*)

g B/kg A	φ_{40}
10.74	219.7
20.10	216.3
33.37	211.6
54.77	204.9

CH_5N

Methylamine

B = $C_6H_5N_3O_4$, 1, 2, 4-Dinitroaniline [48]

M B/l	φ_0
0.161	390.6
0.240	371.3
0.356	339.1
0.512	312.1
0.666	282.0

B = $C_7H_9NO_3S$, *m*-Methoxybenzenesulfonamide [48]

1.27	177.6
1.35	175.5
2.01	90.2
3.76	8.01

B = $C_{12}H_{22}O_{11}$, Sucrose [48]

0.97	29.65
1.44	2.24

C_2HCl_3

Trichloroethylene

B = C_2HCl_5, Pentachloroethane [55, 58]

Wt. % A	φ_{25}
0.0	46.1
17.9	69.5
30.4	86.3
46.5	105.3
63.5	130.7
77.7	150.8
100.0	182.2

C_2HCl_3O

Chloral

B = C_2H_6O, Ethyl alcohol [82]

Wt. % A	φ_{40}	φ_{45}
0.0	125.6	138.9
26.24	88.8	97.0
36.16	71.1	78.7
44.46	57.0	63.7
51.63	45.45	51.2
57.85	35.90	42.03
68.10	24.67	29.7
70.29	22.98	27.93
72.37	21.59	26.54
74.34	21.01	25.93
75.47	21.26	26.40
76.20	21.91	27.23
79.65	25.40	31.24
82.76	30.20	36.54
88.20	44.29	50.28
90.48	50.61	58.00
92.76	56.98	64.85
96.64	74.02	82.03
100.0	99.11	107.07
Wt. % A	φ_{50}	φ_{60}
0.0	152.21	179.9
26.24	106.50	126.74
36.16	87.64	105.71

B = C_2H_6O.—(*Continued*)

Wt. % A	φ_{50}	φ_{60}
44.46	71.58	88.42
51.63	58.75	74.74
57.85	48.2	62.7
68.10	35.1	47.2
70.29	33.3	44.9
72.37	31.8	43.9
74.34	31.2	43.2
75.47	31.8	43.4
76.20	32.6	45.1
79.65	37.0	48.9
82.76	41.8	54.5
88.20	56.9	70.2
90.48	65.4	79.9
92.76	72.5	86.8
96.64	89.3	104.1
100.0	115.1	128.4
Wt. % A	φ_{70}	φ_{85}
0.0	206.2	
26.24	151.7	209.6
36.16	128.2	173.6
44.46	107.6	144.9
51.63	92.4	123.9
57.85	79.2	108.5
68.10	62.5	90.5
70.29	57.4	86.0
72.37	58.2	84.0
74.34	58.6	84.3
75.47	58.6	85.5
76.20	59.5	85.6
79.65	63.8	90.8
82.76	69.0	97.9
88.20	85.9	119.3
90.48	96.1	125.0
92.76	103.5	135.3
96.64	120.9	
100.0	147.7	179.5

°C	φ [82, 83]
74.3 Wt. % A	
40	21.02
45	25.95
50 Wt. % A	
50	31.24
60	43.20
70	58.65
85	84.32
M A/l	φ_{20} [110]
0.25	74.9
0.5	69.7
1.0	62.3

B = $C_5H_{12}O$, *tert.*-Amyl alcohol [38]

M % B	φ_{25}	φ_{40}	φ_{50}
0	79.18	99.11	123.6
10	51.50	61.24	76.3
20	34.14	49.61	62.5
25	26.17	41.44	54.7
30	19.93	33.79	47.3
40	13.53	26.79	39.4
45	11.75	24.71	37.3
50	11.12	23.66	37.9
52.5	11.13	23.62	35.6
55	11.24	23.85	35.8
57.5	11.35	24.02	36.3
60	11.66	24.61	38.1

B = $C_5H_{12}O$.—(*Continued*)

M % B	φ_{25}	φ_{40}	φ_{50}
70	14.53	28.55	42.9
80	19.27	36.42	52.4
90	26.26	46.69	66.1
100	27.05	50.63	71.4
M % B	φ_{70}		φ_{85}
0	147.7		181.5
10	112.2		142.6
20	96.1		125.3
25	91.1		
30	88.3		
40	77.9		111.4
45	74.3		109.8
50	53.1		108.1
52.5	72.0		107.8
55	71.9		107.8
57.5	72.5		106.6
60	75.0		107.6
70	81.8		119.5
80	96.0		136.4
90	113.5		177.9
100	125.3		174.5

$C_2HCl_3O_2$

Trichloroacetic acid

B = $C_2H_4O_2$, Acetic acid [70]

M % A	φ_{25}
0.00	89.2
7.37	65.3
17.77	44.9
32.09	29.74
43.48	23.00
52.62	19.32
58.53	17.06
65.81	14.59
100.00	(14.64)

B = C_3H_6O, Acetone [70]

M % B	φ_{25}
0.00	(14.6)
28.25	17.2
40.29	26.1
49.52	38.9
61.74	69.8
74.57	122.6
86.84	206.0
95.16	271.7
100.00	326.3

B = $C_4H_8O_2$, Ethyl acetate [70]

0.00	(14.64)
29.92	21.23
38.58	28.84
51.22	45.95
61.54	69.0
71.93	99.9
81.60	136.8
88.82	170.2
100.00	236.0

B = C_8H_8O, Acetophenone [70]

0.00	(14.64)
31.85	8.97
42.06	10.72
51.24	13.58
59.10	18.05

B = C_8H_8O.—(*Continued*)

M % B	φ_{25}
70.61	26.78
78.79	34.12
86.00	41.64
91.04	47.35
100.00	59.49

B = $C_4H_{10}O$, Ethyl ether [146]

Wt. % B	φ_{18}
25.40	34.06
37.37	70.13
57.24	164.2
68.82	225.5
82.37	306.6
100.00	417.9

B = $C_9H_{10}O_2$, Ethyl benzoate [70]

M % B	φ_{25}
0.00	(14.64)
32.42	11.94
42.05	14.15
50.93	17.10
60.18	21.69
68.75	26.94
79.04	34.13
91.13	43.03
100.00	50.46

C_2HCl_5

Pentachloroethane

B = C_3H_6O, Acetone [126]

0.00	44.3
14.76	51.8
31.78	65.8
51.03	89.3
70.37	143.9
90.68	239.8
100.00	320.5

B = $C_4H_{10}O$, Ethyl ether [126]

M % B	φ_0
0.00	26.8
13.03	34.0
30.47	48.7
49.68	77.4
74.73	158.7
85.76	224.2
100.00	347.2

B = C_8H_8O, Acetophenone [126]

M % B	φ_{25}
0.00	44.3
11.63	42.7
32.95	42.4
53.38	44.3
73.13	49.3
89.74	55.6
100.00	60.8

B = $C_8H_{10}O$, Phenetole [126]

0.00	44.3
9.71	47.6
22.14	52.1
48.95	62.2
67.98	71.8
90.30	82.9
100.00	89.1

C_2HCl_5.—(*Continued*)

B = $C_{12}H_{10}O$, Phenyl ether (126)

M % B	φ_{25}
0.00	44.3
26.42	37.9
51.09	33.7
76.11	29.8
100.00	27.3

$C_2H_2Cl_4$

1, 1, 2, 2-Tetrachloroethane

B = C_3H_6O, Acetone (126)

M % B	φ_0
0.00	36.1
15.92	43.9
58.07	80.6?
73.08	116.2
81.36	143.9
97.28	229.4
100.00	250

B = $C_4H_{10}O$, Ethyl ether (126)

0.00	36.1
21.15	54.3
47.99	88.5
69.81	147.7
82.68	198.8?
94.01	296.7
100.00	347.2

B = $C_6H_5NO_2$, Nitrobenzene (26)

Wt. % B	φ_5	$\varphi_{76.5}$
0.00	43.6	129.0
10.00	39.4	121.4
30.05	34.2	117.1
48.33	33.3	111.8
69.26	34.4	113.5
89.64	36.0	
100.00	37.1	117.0

B = C_8H_8O, Acetophenone (126)

M % B	φ_{25}
0.00	119.3
12.55	112.0
32.15	97.8
53.97	83.5
73.29	72.4
91.42	64.3
100.00	60.8
Wt. % B	φ_{10} (26)
0.00	48.5
10.19	42.4
30.07	36.0
50.00	35.2
70.01	37.6
90.00	41.6
100.00	44.0
Wt. % B	φ_{80} (26)
0.00	131.1
10.02	126.7
31.20	119.6
69.93	123.6
89.74	132.3
100.00	136.2

B = $C_8H_{10}O$, Phenetole (123)

M % B	φ_0
0.00	36.1
21.76	39.2
51.67	41.5
62.80	44.0
78.37	47.6
100.00	53.1

C_2H_3N

Acetonitrile

B = C_5H_5N, Pyridine (123)

Vol. % B	φ_{25}
0.0	278.6
66.7	172.1

$C_2H_4Br_2$

Ethylene bromide

B = $C_3H_6Br_2$, 1, 2-Dibromopropane; for data at 17, 40, and 85°C, *v.* (157).

B = $C_{12}H_{18}O_8$, Diethyl diacetyltartrate (132)

Wt. % B	$\varphi_{67.3}$	$\varphi_{82.2}$	φ_{99}
0.00	108.5	133.3	154.3
8.43	76.6?	94.5?	108.6?
21.62	96.0?	119.8?	153.6?
53.79	28.02?	42.14?	58.7?
76.58	23.26	36.32	56.5
92.34	14.24	24.41	40.96
100.00	11.17	18.17	32.0

$C_2H_4Cl_2$

Ethylene chloride

B = C_6H_6, Benzene (43); *cf. also* (157)

M % B	φ_0	$\varphi_{19.4}$	φ_{50}
0	92.9	125.0	177.0
30	107.2	144.9	203.3
50	115.2	155.0	219.8
70	119.8	161.3	229.9
80	119.5	162.6	233.6
90	118.7	162.6	237.0
100	117.7	161.6	239.2

B = C_8H_8O, Acetophenone (126)

M % B	φ_{25}
0.00	129.7
30.58	100.7
64.19	77.9
88.82	65.3
100.00	60.8

C_2H_4O

Acetaldehyde

B = C_2H_6O, Ethyl alcohol (97)

Wt. % A	φ_0
0.0	56.5
15.1	48.1
25.2	41.6
30.1	40.0
34.4	38.3
37.1	37.8
40.8	38.55
44.2	40.55

B = C_2H_6O.—(*Continued*)

Wt. % A	φ_0
47.7	40.7
49.1	40.8
53.1	45.9
55.8	49.3
58.6	55.6
65.7	81.2
70.6	103.2
83.0	194.6
100.0	365.0
Wt. % A	φ_{18}
0.00	80.6
10.01	72.7
20.80	67.2
21.61	67.0
30.58	64.8
36.36	64.6
42.01	68.1
52.04	82.3
61.56	120.3
74.10	193.1
81.09	248.8
100.00	411.5

$C_2H_4O_2$

Acetic acid

B = C_3H_6O, Acetone (70)

M % B	φ_{25}
0.00	89.2
9.63	96.5
19.85	108.5
30.32	124.6
40.27	143.0
50.14	164.0
59.51	186.9
69.75	215.7
79.65	247.1
90.04	286.0
100.00	326.3

M % B	φ_0 (43)	φ_{18} (43)	φ_{42} (43)
0	42.02	71.8	99.7
30	76.1	106.8	145.8
60	122.1	171.5	212.8
100	250.0	285.7	357.1

50 Wt. % B (102)

°C	φ
0	104.1
25	150.1
40	187.6
55	219.7
70	250.8

B = $C_4H_6O_3$, Acetic anhydride (26)

Wt. % B	φ_{15}	$\varphi_{76.5}$
0.00	75.0	177.5
9.97	75.9	181.0
30.07	84.4	191.4
49.97	88.2	200.6
69.95	94.6	206.8
89.95	99.4	215.6
100.00	102.1	216.6

B = $C_4H_8O_2$, Isobutyric acid (78)

M % B	φ_{11}
33.34	59.0

B = $C_4H_8O_2$.—(*Continued*)

M % B	φ_{11}
50	53.8
66.67	58.6
100	71.4

B = $C_4H_8O_2$, Ethyl acetate (70)

M % B	φ_{25}
0.00	89.2
12.58	106.0
19.89	116.4
30.12	130.4
40.04	145.1
50.15	158.9
60.10	173.5
69.63	187.6
79.30	202.0
89.51	217.9
100.00	236.0

B = $C_4H_{10}O$, Ethyl ether (146)

Wt. % B	φ_{18}
0.00	71.7
11.55	84.2
15.15	92.4
30.96	128.1
40.37	156.0
50.64	185.9
72.91	284.0
100.00	417.9

B = C_5H_5N, Pyridine (43)

M % B	$\varphi_{18.4}$	φ_{40}
0	74.1	10.0
15	16.64	35.1
17.5	16.3	34.1
20	17.2	34.4
50	35.3	59.5
100	83.3	125.0
M % B	φ_{70}	φ_{99}
0	166.7	232.6
15	69.9	120.5
17.5	69.0	113.0
20	69.9	111.1
50	100.0	133.3
100	181.8	243.9

M % B	φ_{20} (145)
0.0	77.8
10.4	22.6
22.05	19.85
38.3	33.1
40.1	34.6
48.1	45.7
57.9	56.75
73.8	77.6
100.0	107.2
Wt. % B	φ_{25} (120)
0.000	90.1
0.541	86.2
0.985	82.0
3.23	62.1
8.97	36.0
13.22	28.7
17.08	25.0
22.52	26.0
29.00	26.4
100.00	112.5

B = C_5H_5N.—(*Continued*)

23 Wt. % B (102)

°C	φ
0	7.79
25	20.55
40	33.68
55	48.25
70	65.50

For additional data at 20, 40, and 80°C, *v.* (157).

B = C_6H_6, Benzene (29)

Wt. % B	φ_{25}
0.00	85.2
16.74	112.0
34.93	136.2
48.29	150.2
77.26	167.5
81.42	167.7
89.73	169.3
97.25	168.3
100.00	167.3
g B/l	φ_{20} (105)
0.00	79.0
2 414	79.3
5.48	79.8
9.874	81.2
27.38	83.9
49.368	86.1
136.9	98.1
880	151.8

B = C_6H_7N, Aniline (140)

Wt. % B	φ_{25}	φ_{50}
0.0	74.6	
15.5	13.7	33.8
24.7	8.13	
37.9	4.57	17.70
40.9	4.67	17.9
44.5	4.93	19.1
49.55	5.52	
62.3	8.48	26.2
100.0	27.62	49.8

44 Wt. % B (110, 111)

°C	φ
25	5.49
40	12.78
55	23.87
70	38.39

Wt. % B	φ_{25} (120)
0.00	90.1
0.704	84.8
1.72	75.2
4.22	54.6
8.49	32.6
13.85	17.7
16.71	13.0
22.17	8.14
26.58	6.18
28.33	5.63
35.77	4.59
100.00	27.47

M % B	φ_{18} (43)	φ_{59} (43)	φ_{100} (43)
0	99.01	142.9	232.6
20	5.21	34.13	135.1

B = C_6H_7N.—(*Continued*)

M % B	φ_{18} (43)	φ_{59} (43)	φ_{100} (43)
25	4.64	29.7	117.7
30	4.43	28.3	120.5
40	5.12	31.1	125.0
60	11.49	44.8	142.9
80	21.7	57.5	166.7
100	30.5	66.7	192.3

B = $C_6H_{12}O_3$, Paraldehyde (105)

g B/l	φ_{15}
0.00	76.0
3.42	75.9
17.09	75.7
47.73	74.3
85.34	72.5
238.63	67.7
426.73	65.7
707.8	67.4
883.7	71.7
984.8	74.6
990.5	76.0
g B/l	φ_{20}
0.00	82.0
5.49	82.0
9.38	81.9
27.44	81.5
46.90	81.2
85.34	80.6
137.20	80.3
234.51	79.9
426.73	79.4
711.4	79.7
938.1	80.3
972.9	82.2
983.3	82.8
989.3	83.3
994.8	84.9

B = C_8H_8O, Acetophenone (70)

M % B	φ_{25}
0.00	89.21
9.87	77.34
19.98	70.42
30.02	65.62
39.97	62.58
51.15	59.95
57.47	58.72
70.65	57.41
78.93	57.02
90.02	57.45
100.00	59.49

B = $C_9H_{10}O_2$, Ethyl benzoate (70)

M % B	φ_{25}
0.00	89.2
8.68	83.2
20.44	75.6
31.74	69.2
41.78	65.0
52.50	60.6
61.18	57.9
69.55	56.5
78.71	53.4
89.59	51.3
100.00	50.5

C_2H_5I

Ethyl iodide

B = $C_4H_8O_2$, Ethyl acetate (99)

Wt. % B	φ_{25}
0.00	173.3
21.80	245.1
67.43	216.5
100.0	185.5

For data at 18, 35, and 50°C, *v.* (157).

B = $C_8H_{10}O$, Phenetole (124)

M % B	φ_0
0.00	137.9
9.56	129.0
33.98	105.4
54.71	86.1
73.85	71.2
90.89	59.7

C_2H_5NO

Acetamide

B = C_5H_5N, Pyridine (33)

Wt. % B	φ_{25}
83.73	72.4
91.49	91.9
94.35	99.5
96.13	101.3

C_2H_6O

Ethyl alcohol

B = C_2H_6S, Ethylmercaptan (27)

Wt. % B	φ_{25}
0.00	89.5
3.48	95.4
9.47	102.8
12.30	107.5
13.88	114.2
16.25	119.3
32.54	153.2
35.97	163.4
44.76	171.8
68.05	244.9
100.00	478.2

B = C_3H_6O, Allyl alcohol (110)

M B/l	φ_{20}
0.25	81.9
0.5	81.2
1.0	80.9
2.0	80.0
4.0	77.4

B = C_3H_6O, Acetone (105); *cf.* (66)

g B/l	φ_{20}
0.000	79.8
4.809	80.3
7.375	81.1
19.239	83.8
36.876	88.7
43.276	89.6
96.196	103.7
156.860	119.2
184.384	126.4

B = C_3H_6O.—(*Continued*)

Wt. % B	φ_{25} (27)
0.00	89.7
22.46	139.5
27.77	153.6
35.11	172.3
36.83	177.3
43.38	193.7
44.50	198.9
51.57	216.5
70.34	260.7
100.00	320.0

50 Wt. % B (105)

°C	φ
0	129.9
25	189.0
40	237.9

v. also p. 30, A = $Cu(NO_3)_2$ *and* p. 31, A = LiBr; A = KCNS.

B = $C_3H_6O_2$, Methyl acetate (102)

50 Wt. % B

°C	φ
0	111.2
25	163.2
40	202.1
55	241.4

B = C_3H_8O, *n*-Propyl alcohol (55, 112)

Wt. % B	φ_{25}
0.00	91.7
10.0	87.3
20.0	83.5
30.0	79.8
40.0	75.8
50.0	71.3
60.0	67.8
70.0	63.7
80.0	59.9
90.0	56.3
100.0	52.5

B = $C_3H_8O_3$, Glycerol (52)

Wt. % B	φ_{25}	φ_{35}	φ_{45}
0	93.7	115.2	137.7
25	23.9	32.77	43.4
50	4.71	7.40	11.46
75	0.972	1.83	3.215
100	0.165	0.368	0.740

M B/l	φ_{20} (110)
0.25	74.7
0.5	67.0
1.0	56.0

v. also p. 30, A = $CoCl_2$

B = $C_4H_8O_2$, Ethyl acetate (102)

50 Wt. % B

°C	φ
0	104.3
25	144.0
40	185.3
55	226.0

C_2H_6O.—(*Continued*)

B = $C_4H_{10}O$, Ethyl ether [5]

Wt. % B	φ_{25}
0.00	89.9
23.15	134.9
47.43	209.0
57.51	249.7
64.48	278.6
72.99	317.3
78.37	345.2
86.39	379.5
100.00	442.5
Vol. % B	φ_{25} [6]
50	212.4
75	319.7

B = C_5H_5N, Pyridine [110]

M B/l	φ_{20}
0.25	83.0
0.5	84.1
1.0	87.2
2.0	89.9

B = $C_5H_{10}O_4$, Monoacetin [110]

0.25	75.6
0.5	70.2
1.0	58.7
2.0	39.5
4.0	24.2

B = $C_5H_{12}O$, Isoamyl alcohol [105]

g B/l	$\varphi_{18.4}$
0.000	74.9
3.170	73.8
7.350	74.5
8.832	74.5
12.684	73.3
29.44	71.6
44.16	70.9
63.41	69.7
147.20	63.7
220.80	58.4
M B/l	φ_{20} [110]
0.5	76.8
1.0	74.4
2.0	66.0
4.0	54.6

B = C_6H_5ClO, Chlorophenol [136]

21.4 Wt. % B

B	φ_{25}
o-	68.87
m-	68.97
p-	68.78

B = C_6H_6, Benzene [50]; *cf.* [46]

Wt. % B	φ_{15}	φ_{20}	φ_{25}
0	75.7	83.9	91.7
25	90.9	98.3	108.0
50	113.5	123.5	131.8
75	139.5	152.2	160.3
100	142.1	154.1	165.0

B = C_6H_6.—(*Continued*)

Wt. % B	φ_{30}	φ_{35}	φ_{40}
0	101.0	110.0	120.8
25	119.2	129.5	143.1
50	146.8	160.5	176.4
75	175.1	185.9	200.0
100	177.9	189.9	203.3

Wt. % B	φ_{50}	φ_{60}
0	143.3	168.9
100	228.8	255.8

Wt. % B	φ_{63}	φ_{70}
0		198.0
25	202.0	
50		250.0
100		284.9

Wt. % B	φ_{25} [27]
0.00	88.5
8.47	98.7
17.00	104.8
28.90	113.2
45.60	128.9
50.91	137.3
67.58	153.5
69.49	154.7
76.53	164.7
80.38	170.0
88.03	176.4
98.86	176.5
100.00	171.8
g B/l	φ_{20} [105]
0.000	77.2
2.708	77.6
3.120	77.6
4.242	77.59
10.832	78.4
15.588	79.05
23.208	79.3
54.160	81.1
97.984	86.3

50 Wt. % B [102]

°C	φ
0	70.71
25	121.9
40	161.3
55	201.5

B = $C_6H_6O_2$, Hydroquinol [110]

M B/l	φ_{20}
0.25	73.2
0.5	64.7
1.0	51.9

For *o*- and *m*- isomers at 20°C, *v.* [152.1].

B = $C_6H_{10}O_3$, Ethyl acetoacetate [35]

Wt. % B	φ_{25}
0.00	93.7
8.05	97.7
36.28	103.9
46.71	102.1
64.02	96.4
100.00	66.3

B = C_6H_{12}, Cyclohexane; for data at 20°C, *v.* [152.2].

B = $C_6H_{12}O_3$, Paraldehyde [105]

g B/l	φ_{20}
0.0	79.8
5.64	79.9
8 33	80.3
22.56	81.3
41.68	81.9
112.8	85.1
208.4	89.2
994.8	84.9

B = $C_6H_{14}O_2$, Acetal [110]

M B/l	φ_{20}
0.25	85.4
0.5	87.9
1.0	95.4

B = C_7H_6O, Benzaldehyde [27]

Wt. % B	φ_{25}
0.00	89.9
11.65	91.6
20.67	95.2
23.60	95.2
32.47	96.1
53.96	86.4
79.32	76.5
90.63	73.4
100.00	69.2

B = $C_7H_6O_2$, Salicylaldehyde; for data at 20°C, *v.* [152.1].

B = C_7H_8O, Anisole [5]

Wt. % B	φ_{25}
0.00	89.9
15.21	95.7
29.62	101.1
43.00	105.6
55.67	108.9
67.68	110.6
79.05	110.5
89.98	108.2
100.00	99.2

B = $C_7H_8O_2$, *o*-Hydroxybenzyl alcohol [110]

M B/l	φ_{20}
0.25	75.5
0.5	68.3
1.0	58.4

B = $C_7H_8O_2$, Guaiacol; for data at 20°C, *v.* [152.1].

B = $C_8H_{10}O$, Phenetole [5]

Wt. % B	φ_{25}
0.00	89.9
14.97	93.7
28.89	96.6
42.32	99.0
54.97	100.3
67.05	100.9
78.50	100.0
90.25	96.6
100.00	88.1

B = $C_8H_{10}O_2$, *o*-Dimethoxybenzene; for data at 20°C, *v.* [152.1].

B = $C_8H_{14}O_3$, Ethyl ethylacetoacetate [35]

Wt. % B	φ_{25}
0.00	92.7
5.44	94.0
23.80	96.3
41.24	94.5
71.31	83.1
87.87	72.2
100.00	59.6

B = C_9H_7N, Quinoline [74]

0.00	92.7
13.30	91.6
23.50	78.56
39.09	71.4
50.23	60.95
62.65	53.28
68.98	49.6
75.69	41.30
85.57	38.70
92.09	34.29
100.00	29.75

B = $C_{10}H_7Br$, α-Bromonaphthalene [110]

M B/l	φ_{20}
0.25	78.6
0.5	75.7
1.0	71.5

B = $C_{10}H_{12}$, 1, 2, 3, 4-Tetrahydronaphthalene [59]

Wt. % B	φ_{25}
0.0	92.0
24.6	85.4
48.3	78.4
75.8	67.0
92.3	57.3
100.0	49.9

v. also [152.2]

B = $C_{10}H_{12}O$, Anethole and *ar*-Tetrahydro-β-naphthol; for data at 20°C, *v.* [152.2].

B = $C_{10}H_{16}O$, Camphor [110]

M B/l	φ_{20}
0.25	80.6
0.5	76.9
1.0	73.2
2.0	66.1

B = $C_{10}H_{18}O_3$, Ethyl diethylacetoacetate [35]

Wt. % B	φ_{25}
0.00	93.7
15.66	91.4
20.74	90.3
28.56	87.9
91.78	45.7
100.00	35.8

B = $C_{14}H_{10}O_2$, Benzil (143)

g B/kg A	φ_{15}
0.00	75.9
6.82	75.6
11.36	75.3
20.39	74.9
g B/kg A	φ_{40}
0.00	119.3
12.06	118.0
25.74	116.7
38.24	115.5
47.17	114.4

B = $C_{18}H_{36}O_2$, Stearic acid (110)

M B/l	φ_{20}
0.25	77.2
0.5	71.4
1.0	61.5

B = $C_{22}H_{20}O_{13}$, Carminic acid (154)

0.03125	77.4
0.0625	73.4
0.125	66.1

B = $C_{34}H_{47}NO_{11}$, Aconitine (110)

0 02	80.4
0.04	77.7

C_2H_7N

Dimethylamine

B = C_2H_8ClN, Dimethylamine hydrochloride (40)

M B/l	$\varphi_{-32.5}$
0.2843	189.3
0.3585	181.9
0.7857	135.9
0.8535	111.8

C_2H_7N

Ethylamine

B = C_2H_8ClN, Ethylamine hydrochloride (40)

M A/l	$\varphi_{-33.5}$
0.09458	162.2
0.1898	150.7
0.3817	131.3
0.7518	101.4
1.489	53.7

$C_3H_3N_3O_3$

Cyanuric acid

B = C_5H_5N, Pyridine (33)

Wt. % B	φ_{25}
96.8	96.3

C_3H_5NS

Ethyl thiocyanate

B = $C_6H_{11}N$, Piperidine (91)

M % B	φ_{50}
0	208.3
5	176.4
25	59.5
45	4.42
50	0.924
55	2.06
75	22.8
95	92.9
100	118.3

C_3H_6O

Acetone

B = C_3H_8O, Isopropyl alcohol (158)

B = $C_4H_{10}O$, Ethyl ether (43)

M % B	φ_0	φ_{14}	φ_{32}
0	261.1	307.7	387.6
30	287.4	341.3	408.2
70	325.1	380.2	438.6
100	333.3	400.0	465.1

B = C_6H_5Br, Bromobenzene

M % B	φ_0 (126)
0.00	250.0
6.25	225.2
17.50	186.6
28.15	158.2
50.15	115.9
73.54	85.4
84.32	78.3
100.00	66.7

B = C_6H_5Cl, Chlorobenzene

M % B	φ_0 (126)
0.00	250.0
4.03	238.7
15.26	208.8
39.70	166.1
50.88	143.5
84.70	104.9
100.00	96.7

B = C_6H_5ClO, *o*-Chlorophenol (17)

Wt. % B	φ_0	φ_{10}	φ_{20}
0.00	253.0	277.8	309.2
18.49	171.8	189.8	210.5
32.38	127.1	144.5	163.7
49.95	71.5	86.1	100.8
60.49	46.8	59.45	72.7
71.01	27.86	37.38	48.76
83.22	14.82	22.37	31.55
91.73	10.64	17.24	25.58
100.00	9.27	15.65	23.75
Wt. % B	φ_{30}	φ_{40}	φ_{50}
0.00	339.0	370.4	403
18.49	238.7	261.8	284
32.38	175.7	196.9	215
49.95	112.0	128.7	145.6
60.49	83.4	98.1	112.0
71.01	59.4	73.1	86.7
83.22	41.7	53.0	65.5
91.73	35.1	46.2	57.6
100.00	32.5	43.1	53.5

Wt. % B	φ_{60}	φ_{70}
59.37	137.2	156.0
68.23	108.9	126.4
76.99	90.3	105.0
84.64	77.6	92.0
91.08	70.3	84.2
100.00	66.1	79.0

B = $C_6H_5NO_2$, Nitrobenzene

Vol. % B	φ_{25} (47)
0	317.5
25	203.9
50	139.1
75	92.1
100	55.2
g B/l	φ_{20} (105)
937.7	74.1
1037.7	66.1
1080.7	61.0
1150.8	54.0
1177.1	52.4
1183.2	51.8
1192.2	51.2
1197.1	50.5
1204.8	49.64

B = C_6H_6, Benzene (13)

Wt. % B	φ_{10}	φ_{20}	φ_{30}
0.0	278.8	309.6	342.3
21.24	251.2	280.5	311.1
49.34	213.2	240.9	268.2
72.14	173.9	203.6	230.2
100.00	131.9	154.7	178.7

Vol. % B	φ_{25} (47)
0	317.4
25	285.1
50	250.2
75	212.1
100	173.7
g B/l	φ_{20} (105)
699.8	185.8
789.3	172.0
840.5	162.1
858.8	159.1
869.7	157.4
873.5	156.4
880.0	155.6

B = C_6H_6O, Phenol (17)

Wt. % B	$\varphi_{9.95}$	$\varphi_{20.05}$
0.00	277.8	309.6
14.19	205.8	233.1
26.72	157.5	178.6
38.06	115.2	132.4
49.43	79.6	94.8
57.79	59.2	72.5
65.22	42.4	54.0
73.74	27.25	36.4
78.94	20.2	27.9
85.39	13.37	20.1
92.85	8.38	13.7
100.00	4.98	9.06
Wt. % B	$\varphi_{29.8}$	$\varphi_{40.1}$	$\varphi_{49.8}$
0.00	339.0	370.4	403.2
9.57	277.8	304.9	334.4
19.53	226.8	250.6	277.8
27.70	191.9	212.8	237.0
37.42	149.3	169.5	188.7
44.67	123.8	140.6	159.2
53.79	94.5	110.6	125.9
60.24	75.8	90.8	105.3
67.19	60.3	73.4	87.0
74.25	45.9	57.4	70.2
80.76	36.4	44.8	56.0
87.98	25.5	34.8	44.5
92.81	20.4	28.9	38.2
100.00	14.1	21.1	30.5

B = $C_6H_6O_2$, *o*- and *m*-Dihydroxybenzene; for data at 20°C, *v.* (152.1).

B = C_6H_7N, Aniline (43)

M % B	φ_{18}	φ_{41}
0	333.3	400.0
40	115.9	170.1
70	53.3	90.1
100	29.6	48.2

50 Wt. % B (102)

°C	φ
0	70.3
25	113.4
40	146.7
55	176.5
70	205.2

B = C_6H_{12}, Cyclohexane; for data at 20°C, *v.* (152.2).

B = C_6H_{14}, Hexane (105)

g B/l	φ_{20}
572.2	295.2
623.8	289.0
684.3	280.4
685.1	276.5
687.2	276.0

B = $C_7H_6O_2$, Salicylaldehyde; for data at 20°C, *v.* (152.1).

B = $C_7H_8O_2$, Guaiacol; for data at 20°C, *v.* (152.1).

B = $C_7H_{14}O_2$, Amyl acetate (31)

Wt. % B	φ_{25}
81.60	160.7
91.41	145.4
100.00	126.7

B = $C_8H_{10}O_2$, *o*-Dimethoxybenzene; for data at 20°C, *v.* (152.1).

B = $C_{10}H_8O$, β-Naphthol; for data at 20°C, *v.* (152.2).

B = $C_{10}H_{12}$, Tetrahydronaphthalene; for data at 20°C, *v.* (152.2).

B = $C_{10}H_{12}O$, *ar*-Tetrahydro-β-naphthol; for data at 20°C, *v.* (152.2).

B = $C_{12}H_{10}O$, Phenyl ether (126)

M % B	φ_{25}
0.0	320.5
10.60	227.8
26.94	140.1
51.57	74.7
100.00	27.3

$C_3H_6O_2$

Propionic acid

B = C_5H_5N, Pyridine; for data at 20, 40, and 80°C, *v.* (157).

$C_3H_6O_2$

Methyl acetate

B = $C_4H_8O_2$, Ethyl acetate (78)

M % B	φ_{11}
0	162.2
25	158.6
50	155.8
66.58	153.4

C_3H_7NO

Methylacetamide

B = C_5H_5N, Pyridine (33)

Wt. % B	φ_{25}
83.56	92.4
88.80	97.9
93.41	103.4

C_3H_7NO

Propionamide

B = C_5H_5N, Pyridine (33)

76.25	61.9
86.34	82.9
92.08	95.5

$C_3H_7NO_2$

Urethane

B = C_5H_5N, Pyridine (33)

85.04	83.2
90.91	93.5

C_3H_8O

n-Propyl alcohol

B = $C_3H_8O_3$, Glycerol (110)

M B/l	φ_{20}
1.0	29.6

B = $C_4H_{10}O$, Ethyl ether (5)

Wt. % B	φ_{25}
0.0	50.7
11.93	71.2
22.99	97.7
34.92	132.8
47.16	178.0
59.89	234.0
72.97	298.2
86.22	368.1
100.0	442.5

C_3H_8O

n-Propyl alcohol

B = C_6H_6, Benzene (29)

0.0	51.0
4.93	85.7
10.01	142.3
29.78	166.9
66.90	169.0
100.0	167.3

B = C_6H_7N, Aniline (78)

M % B	φ_{12}	φ_{64}
0	38.3	166.8
20	36.8	160.5
65	26.4	128.8
100	17.2	99.4

$C_3H_8O_3$

Glycerol

B = $C_5H_{12}O$, Isoamyl alcohol (111)

M A/l	φ_{20}
1.0	14.47

$C_4H_5Cl_3O_2$

Ethyl trichloroacetate

B = $C_4H_8O_2$, Ethyl acetate (78)

M % A	φ_{11}
22.82	110.9
50	80.4
63.47	72.0
100.00	47.6

C_4H_5NS

Allyl thiocyanate

B = C_5H_5N, Pyridine (92)

M % B	φ_{25}
0	148.6
50	138.5
100	117.1

B = $C_5H_{11}N$, Piperidine (92)

M % B	φ_{25}	φ_{50}	φ_{80}
0	148.6	184.8	234.2
10	85.5		
25	24.08		
40	2.68		
40.91	2.64		22.8
45	0.846	4.21	13.27
48	0.402	2.88	12.75
50	0.283	1.82	10.71
52	0.384	2.37	12.78
55	0.581	3.22	13.06
60	1.467		
75	9.57		
90	38.8		134.1
100	73.4	118.3	135.5

B = C_6H_7N, Aniline (86)

M % B	φ_{100}	φ_{125}
0	316.5	380
10	221.2	274.0
20	127.4	158.7
30	54.3	69.3
40	22.7	35.8
48	12.07	27.6
50	11.03	26.6
52	12.71	29.0
60	24.9	43.6
70	45.7	73.9
80	74.5	110.0
90	109.6	160.5
100	144.7	203.3

B = C_7H_8, Toluene (86)

M % B	φ_{85}	φ_{100}
25	297	325
50	315.5	351
75	333	357

B = C_7H_9N, Methylaniline (91)

M % B	φ_{25}	φ_{50}
0	148.6	184.8
10	85.3	115.5
25	39.2	47.06

B = C_7H_9N.—(*Continued*)

M % B	φ_{25}	φ_{50}
40	9.82	19.76
48	3.24	10.29
50	2.85	8.64
52	3.17	
55	3.98	12.00
60	6.22	17.5
75	18.6	40.3
90	31.9	62.5
100	50.0	67.8

$C_4H_6O_3$

Acetic anhydride

B = $C_6H_{12}O_3$, Paraldehyde (26)

Wt. % B	φ_{10}	$\varphi_{76.5}$
0.00	94.5	216.6
10.00	89.2	212.3
29.96	82.1	211:0
50.00	75.2	206.7
69.99	69.3	205.1
90.02	66.4	207.1
100.00	65.5	209.2

$C_4H_8O_2$

Butyric acid

B = C_5H_5N, Pyridine; for data at 18, 30 and 40°C, *v.* (157).

$C_4H_8O_2$

Ethyl acetate

B = C_5H_5N, Pyridine (102)

50 Wt. % B

°C	φ
0	122.0
25	170.0
40	194.0
55	219.2

B = $C_6H_5NO_2$, Nitrobenzene (99)

Wt. % B	φ_{25}
0.00	229.9
22.90	171.8
56.10	112.5
75.53	83.1
100.00	54.5

50 Wt. % B (102)

°C	φ
0	84.02
25	122.6
40	153.8
55	179.3
70	202.9

B = C_6H_6, Benzene (27); *cf.* (99)

Wt. % B	φ_{25}
0.00	238.5
24.05	224.9
50.90	209.1
51.70	208.2
56.07	207.0
64.16	200.4
66.90	200.4
72.96	193.0
100.00	171.8

B = C_6H_6.—(*Continued*)

50 Wt. % B (102)

°C	φ
0	149.3
25	206.6
40	251.2
55	289.5

B = C_6H_7N, Aniline (153)

M % B	φ_0
0.0	170.0
15.2	122.2
22.34	104.0
42.8	63.6
50.77	53.9
67.2	34.8
74.9	25.8
77.6	23.5
84.2	19.0
88.9	14.2
93.9	12.5
100.0	10.03

B = C_7H_8, Toluene (99)

Wt. % B	φ_{25}
0.0	216.5
15.71	214.6
45.30	207.9
71.26	196.5
100.00	185.5

B = $C_7H_{14}O_2$, Iso (?) amyl acetate (78)

M % B	φ_{11}
20.6	111.4
50	105.0
100	63.3

B = $C_8H_{14}O_4$, Diethyl succinate (78)

M % B	φ_{12}	φ_{64}
0	151.7	304.8
25	101.4	221.5
50	67.8	176.7
62.5	52.9	157.4
75	45.8	146.3
90	33.4	130.1
100	29.9	119.9

B = $C_9H_{10}O_2$, Ethyl benzoate (73)

M % B	φ_{25}
0.00	235.9
10.08	192.7
20.03	161.9
30.11	138.0
40.02	118.0
49.56	101.5
60.27	86.4
68.69	77.4
79.12	66.0
87.84	58.7
100.00	49.6

M % B	φ_{12} (78)	φ_{64} (78)
0	151.7	302.9
25	111.2	240.3
40	62.7	
75	55.4	158.7
100	38.7	133.4

B = $C_{10}H_{22}O$, Isoamyl ether (78)

Wt. % B	φ_{11}
16.83	133.4
43.50	113.2
74.95	88.2
100.00	71.4

B = $C_{14}H_{12}O_2$, Benzyl benzoate (73)

M % B	φ_{25}
0.0	235.9
10.2	156.1
20.10	109.7
30.27	78.4
41.37	55.9
50.00	43.5
59.99	32.8
69.98	25.77
76.53	21.23
85.74	16.84
92.16	14.28
100.00	11.74

$C_4H_9NO_2$

Methylurethane

B = $C_{10}H_{20}O$, Menthol (132)

Wt. % B	$\varphi_{55.6}$	$\varphi_{74.6}$
0.00	43.9	72.9
33.38	38.0	68.2
56.80	32.8	55.9
74.28	25.8	59.5
84.39	25.9	53.4
92.46	20.1	42.4
100.00	15.9	40.5
Wt. % B	$\varphi_{82.2}$	φ_{99}
0.00	80.8	118.1
33.38	81.0	
56.80	101.4	101.4
74.28	74.6	116.9
84.39	66.9	95.1
92.46	54.5	88.7
100.00	54.0	96.1

$C_4H_{10}O$

Butyl alcohol

B = $C_{10}H_{12}$, 1, 2, 3, 4-Tetrahydronaphthalene (59)

Wt. % B	φ_{25}
0.00	40.6
28.34	47.6
57.13	53.8
71.30	56.0
84.90	56.1
100.00	49.9

B = $C_{10}H_{18}$, Decahydronaphthalene (59)

0.00	40.6
32.38	44.4
49.43	46.5
67.12	47.9
82.59	47.1
89.80	46.1
100.00	41.4

$C_4H_{10}O$

Ethyl ether

B = C_6H_6, Benzene (99)

Wt. % B	φ_{25}
0.00	434.8
28.58	354.6
56.92	276.2
75.69	228.3
100.00	166.9

(50)

Wt. % B	φ_{15}	φ_{20}	φ_{25}
0	404.9	425.5	448.4
25	320.5	333.3	347.2
50	253.2	262.5	273.8
75	186.2	207.5	219.2
100	142.1	154.1	165.0

Wt. % B	φ_{30}	φ_{35}
0	471.7	
25	359.7	
50	289.0	310.6
75	232.6	245.1
100	177.9	189.8

(13)

Wt. % B	φ_{10}	φ_{20}	φ_{30}
0.00	386.0	426.5	469.4
35.15	287.2	319.8	353.2
55.58	235.3	264.3	295.5
79.52	176.7	203.4	230.6
100.00	131.9	154.7	178.7

B = $C_6H_6O_2$, *o*- and *m*-Dihydroxybenzene; for data at 20°C, *v.* (152.1).

B = $C_6H_{14}O_2$, Acetal (124, 125)

M % B	φ_0	φ_{25}
0.00	347	446
9.97	266	
21.62		263
28.18	158	
45.12		149.5
46.04	89.8	
69.73		73.6
70.90	37.9	
87.32	19.2	
100	10.0	27.5

B = $C_7H_6O_2$, Salicylaldehyde; for data at 20°C, *v.* (152.1).

B = C_7H_8, Toluene (50)

Wt. % B	φ_{15}	φ_{20}	φ_{25}
0	404.9	423.7	448.4
25	319.5	333.0	344.8
50	253.8	263.9	277.8
75	206.6	213.7	224.7
100	159.5	170.6	180.8

Wt. % B	φ_{30}	φ_{35}
0	471.7	
25	355.9	367.6
50	289.9	302.1
75	238.7	247.5
100	192.3	212.8

B = C_7H_8O, Benzyl alcohol (6)
φ_{25} = 101.3 with 50 Vol. % B

B = $C_7H_8O_2$, Guaiacol; for data at 20°C, *v.* (152.1).

B = $C_8H_{10}O$, Phenetole (73)

M % B	φ_{25}
0.0	447.8
9.96	374.0
16.97	327.1
25.18	286.2
31.18	258.7
39.52	227.0
44.21	207.9
48.94	194.0
54.99	175.0
64.84	150.0
69.74	139.8
74.77	127.3
81.45	115.3
90.25	100.1
92.55	97.4
100.00	86.5

B = $C_8H_{10}O_2$, *o*-Dimethoxybenzene; for data at 20°C, *v.* (152.1).

B = $C_{12}H_{10}O$, Phenyl ether (73)

M % B	φ_{25}
0.0	447.8
9.8	322.0
21.74	219.7
29.12	174.4
39.24	131.4
48.98	100.7
57.55	79.5
67.03	61.3
78.07	46.4
86.82	36.5
92.96	31.7
100.00	25.9

$C_4H_{11}N$

Diethylamine

B = C_7H_5NS, Phenyl thiocyanate (86)

M % B	φ_{25}	φ_{35}
0	289.0	358.4
10	151.3	178.6
25	17.14	25.9
33.3	2.562	4.574
40	0.1898	0.4404
45	0.0385	0.1049
48	0.01129	0.0450
50	0.00270	0.0204
52	0.0246	0.09575
55	0.0576	0.202
60	0.5057	1.267
75	8.970	13.4
90	38.0	46.3
100	71.6	83.4

M % B	φ_{50}
45	0.710
48	0.303
50	0.189
52	0.522
55	0.765
60	3.644
75	22.54
90	60.39
100	102.25

C_5H_5N

Pyridine

B = C_6H_5ClO, *o*-Chlorophenol (17)

Wt. % B	φ_0	φ_{10}	φ_{20}
0.00	75.6	90.2	106.3
11.17	60.2	72.4	86.4
21.62	46.0	56.7	68.5
31.57	33.5	42.5	52.5
42.31	22.5	29.8	38.2
51.48	14.08	19.7	27.1
60.15	8.35	13.0	18.94
67.47	5.47	9.29	14.66
72.51	4.38	7.84	12.82
76.93	3.80	7.22	12.15
81.06	3.71	7.13	12.26
85.17	3.99	7.54	13.19
92.51	5.52	9.96	16.75
100.00	9.27	15.65	23.75
Wt. % B	φ_{30}	φ_{40}	φ_{60}
0.00	121.8	140.1	173.0
11.17	100.6	115.9	145.8
21.62	80.1	93.2	120.5
31.57	63.0	74.0	98.5
42.31	46.5	56.4	77.5
51.48	33.8	43.3	62.8
60.15	25.5	33.56	51.7
67.47	21.2	28.33	45.8
72.51	19.2	26.46	43.8
76.93	18.5	26.04	43.7
81.06	18.66	26.46	44.8
85.17	19.84	28.17	47.4
92.51	24.33	34.01	54.5
100.00	32.47	43.10	66.1

Wt. % B	φ_{80}	φ_{110}
0.00	205.3	259.7
11.17	176.1	223.2
21.62	148.8	193.8
31.57	124.7	166.7
42.31	101.4	142.0
51.48	84.4	125.3
60.15	73.0	113.0
67.47	67.25	105.8
72.51	65.4	103.7
76.93	65.3	104.0
81.06	66.9	106.2
85.17	70.2	110.4
92.51	79.6	119.5
100.00	93.5	131.6

B = $C_6H_5NO_3$, *o*-Nitrophenol (17)

Wt. % B	φ_{30}	φ_{40}
0.00	121.8	140.1
11.32	106.0	122.7
20.74	92.5	107.5
27.58	82.6	97.1
39.62	66.7	80.3
52.25	53.2	66.2
60.24	46.5	58.4
68.32	40.8	52.3
76.79	36.3	46.6
86.96	31.8	41.5
91.25	30.0	39.6
100.00	27.4	36.3

C_5H_5N.—(*Continued*)

B = $C_6H_5NO_3$.—(*Continued*)

Wt. % B	$\varphi_{60.1}$	φ_{80}
0.00	173.0	205.3
11.32	154.6	185.5
20.74	139.1	169.5
27.58	127.2	157.5
39.62	108.1	138.1
52.25	91.6	119.6
60.24	82.5	109.8
68.32	75.5	100.8
76.79	68.5	92.6
86.96	61.7	83.7
91.25	59.2	80.6
100.00	54.8	74.2

B = C_6H_6O, Phenol (17)

Wt. % B	φ_{10}
0.00	90.2
17.26	62.7
26.01	48.8
35.14	37.4
45.48	26.6
51.89	19.8
58.46	14.71
66.99	10.12
76.81	7.06
82.86	6.08
91.89	5.32
100.00	4.96

Wt. % B	φ_{20}	φ_{30}	φ_{40}
0.00	106.3	121.8	140.1
8.30	90.2	106.4	120.8
16.12	75.7	90.4	103.6
24.36	62.6	74.7	86.8
32.58	49.8	61.2	72.0
38.94	41.5	50.94	61.3
47.13	31.1	39.77	49.0
54.96	22.9	30.82	39.1
63.81	16.83	23.31	30.8
70.49	13.37	19.34	26.3
77.94	11.02	16.56	23.2
85.17	9.96	15.10	21.8
92.45	9.33	14.46	21.3
100.00	9.06	14.10	21.1

Wt. % B	φ_{60}	φ_{80}	φ_{110}
0.00	173.0	205.3	259.7
8.30	152.4	183.8	233.6
16.12	132.8	162.9	210.5
24.36	113.8	140.2	186.9
32.58	96.9	122.7	165.0
38.94	83.5	107.1	149.5
47.13	69.6	92.8	133.2
54.96	57.9	79.2	118.9
63.81	48.4	69.2	107.0
70.49	43.5	63.3	101.2
77.94	40.0	60.4	98.7
85.17	40.0	59.9	98.8
92.45	38.6	60.6	101.5
100.00	39.7	63.3	106.3

B = C_6H_7N, Aniline (43)

M % B	φ_0	φ_{19}
0	71.4	87.0
50	27.7	48.8
100	11.6	29.1

B = C_6H_7N.—(*Continued*)

M % B	$\varphi_{58.6}$	φ_{100}
0	170.1	250.0
50	105.2	200.0
100	66.7	160.0

Vol. % B	φ_{25} (121)
0	112.2
50	53.8
80	36.6
100	27.0

B = $C_6H_{10}O_3$, Ethyl acetoacetate (35)

Wt. % B	φ_{25}
0.00	113.6
17.11	107.6
32.09	100.8
51.00	91.74
71.07	81.10
100.00	66.31

B = $C_7H_6O_2$, Benzoic acid (8)

Wt. % B	φ_{110}	φ_{125}
0	272.8	
40	114.2	141.0
50	95.1	116.9
56	78.1	99.0
60	74.7	95.5
62	74.6	95.9
63	69.6	90.4
66.66	64.4	86.7
69	66.4	86.0
72	67.2	89.8
78	67.4	87.6
82	66.8	87.0
86	66.5	85.2
92		87.0
100		94.9

B = C_7H_7NO, Benzamide (34)

Wt. % B	φ_{25}
5.16	94.8
12.46	75.1

B = C_7H_7NO, Formanilide (33)

10.32	91.8
19.14	74.9

B = C_7H_8O, *o*-Cresol (17)

Wt. % B	φ_0	φ_{10}	φ_{20}
0.00	75.6	90.2	106.3
12.05	59.9	71.6	85.0
24.55	42.8	52.6	64.3
33.60	31.7	40.2	50.4
45.83	18.81	25.6	33.76
55.91	10.68	15.8	22.45
66.83	5.48	9.36	14.61
77.73	3.17	6.20	10.80
85.72	2.65	5.52	9.96
91.85	2.55	5.44	9.99
100.00	2.52	5.59	10.46

Wt. % B	φ_{30}	φ_{40}	φ_{60}
0.00	121.8	140.1	173.0
12.05	97.8	112.9	142.2
24.55	74.1	87.1	112.5
33.60	58.0	69.6	93.6
45.83	39.1	48.9	70.2
55.91	27.6	36.4	56.0

B = C_7H_8O.—(*Continued*)

Wt. % B	φ_{30}	φ_{40}	φ_{60}
66.83	20.26	28.0	45.8
77.73	16.05	23.3	40.6
85.72	15.23	22.6	40.6
91.85	15.50	23.1	41.7
100.00	16.33	24.4	44.6

Wt. % B	φ_{80}	φ_{110}
0.00	205.3	259.7
12.05	170.4	221.7
24.55	138.9	184.2
33.60	117.4	162.6
45.83	94.3	136.6
55.91	79.8	119.9
66.83	68.2	105.8
77.73	63.05	102.0
85.72	63.6	103.2
91.85	65.45	106.2
100.00	69.9	111.5

B = C_7H_8O, *m*-Cresol (17)

Wt. % B	φ_0	φ_{10}	φ_{20}
0.00	75.6	90.2	100.6
14.09	55.8	68.2	81.4
27.45	37.8	47.5	56.5
41.40	23.36	30.8	39.4
46.92	18.05	24.9	32.4
55.33	11.39	16.85	23.5
61.80	7.79	12.44	17.91
70.62	4.53	7.78	12.26
75.90	3.23	6.01	10.12
85.17	2.00	4.22	7.65
91.41	1.56	3.50	6.75
100.00	1.19	2.89	5.92

Wt. % B	φ_{30}	φ_{40}	φ_{60}
0.00	121.8	140.1	173.0
14.09	91.1	107.4	136.8
27.45	68.4	80.6	105.4
41.40	47.1	57.7	78.9
46.92	39.8	49.45	70.5
55.33	29.85	38.4	57.0
61.80	23.95	31.75	49.5
70.62	17.95	25.03	41.2
75.90	15.34	21.9	38.2
85.17	12.68	19.0	35.1
91.41	11.57	17.9	33.8
100.00	10.56	16.9	33.4

Wt. % B	φ_{80}	φ_{110}
0.00	205.3	259.7
14.47	166.9	218.8
26.75	136.8	185.5
38.43	111.0	154.8
50.72	87.2	129.0
61.52	71.1	109.9
70.94	61.4	99.0
82.33	55.0	93.1
90.88	54.1	95.1
100.00	55.2	97.8

B = C_7H_8O, *p*-Cresol (17)

Wt. % B	φ_0	φ_{10}	φ_{20}
0.00	75.6	90.2	106.3
21.03	45.9	54.4	68.9
29.61	35.8	44.4	55.3
40.04	24.0	31.5	39.46
46.71	17.26	23.78	32.21
54.46	11.53	16.69	23.72

B = C_7H_8O.—(*Continued*)

Wt. % B	φ_0	φ_{10}	φ_{20}
60.37	8.06	12.71	18.81
67.82	5.24	8.77	13.59
75.36	3.205	5.97	9.96
83.28	2.005	4.17	7.55
91.01	1.381	3.21	6.19
100.00	1.016	2.52	5.28

Wt. % B	φ_{30}	φ_{40}	φ_{60}
0.00	121.8	140.1	173.0
21.03	73.4	87.8	120.9
29.61	61.4	73.0	100.5
40.04	47.28	57.9	80.4
46.71	38.99	48.4	68.4
54.46	30.21	38.5	56.4
60.37	24.51	32.1	49.5
67.82	18.99	26.1	42.6
75.36	15.07	21.46	37.0
83.28	12.55	18.46	33.7
91.01	10.80	16.61	31.7
100.00	9.49	15.29	30.5

Wt. % B	φ_{80}	φ_{110}
0.00	205.3	259.7
14.06	165.8	217.2
27.48	133.9	181.4
41.10	104.7	147.8
54.03	81.3	121.6
63.11	68.4	106.4
71.88	59.0	95.5
81.72	52.9	89.3
89.95	51.0	90.0
100.00	51.6	92.5

B = $C_8H_5NO_2$, Phthalimide (33)

Wt. % B	φ_{25}
5.05	101.2
11.93	84.6

B = $C_8H_{14}O_3$, Ethyl ethylacetoacetate (35)

0.00	113.3
12.70	106.9
40.62	90.8
63.99	78.9
85.33	67.1
100.00	59.6

B = $C_{10}H_{18}O_3$, Ethyl diethylacetoacetate (35)

0.00	113.6
2.83	111.5
6.91	108.4
21.10	98.5
50.83	74.2
100.00	35.8

B = $C_{13}H_{11}NO$, Benzanilide (33)

5.40	97.4
9.02	89.2
12.75	79.9

B = $C_{13}H_{12}N_2O$, 1, 2-Diphenylurea (33)

5.69	95.7
7.19	92.7

B = $C_{13}H_{12}N_2S$, 1, 2-Diphenyl-thiourea (33)

Wt. % B	φ_{25}
7.40	86.3
14.51	70.6

B = $C_{14}H_9NO_2$, Phthalanil (33)

3.55	104.1

C_5H_8O

Ethyl propargyl ether

B = $C_7H_{14}O_2$, Isoamyl acetate (60)

Wt. % B	φ_{25}
0.00	189.8
84.92	137.0
91.55	132.6
100.00	126.6

$C_5H_{10}O$

Ethyl allyl ether

B = $C_7H_{14}O_2$, Isoamyl acetate (60)

0.00	289.7
89.42	143.3
94.36	135.1

$C_5H_{10}O_2$

n-Propyl acetate

B = $C_6H_{12}O_2$, Isoamyl formate (78); *cf.* (55)

M % B	φ_{12}	φ_{64}
0.0	113.1	271.2
25.8	123.3	260.9
70.1	112.7	249.1
100.0	105.9	237.7

$C_5H_{12}O$

Isoamyl alcohol

B = $C_6H_5NO_2$, Nitrobenzene (26)

Wt. % B	φ_0	φ_{80}
0.00	11.32	112.7
9.98	13.82	122.6
29.98	19.00	133.6
50.02	23.75	143.5
70.00	29.90	144.1
90.00	34.90	134.1
100.00	33.02	120.3

B = C_6H_6, Benzene (108)

g B/l	$\varphi_{18.4}$
549.5	104.6
708.0	132.6
761.9	139.1
799.4	144.05
857.0	146.8
864.4	147.0
864.6	148.7
872.0	148.1
880.0	148.1

B = $C_6H_{12}O_2$, Paraldehyde (26)

Wt. % B	φ_{10}	$\varphi_{76.5}$
0.00	16.12	105.3
10.01	21.09	121.8
30.00	32.19	147.1
50.00	44.70	174.8
69.98	56.27	199.0
90.02	64.48	208.6
100.00	65.46	209.2

B = C_6H_{14}, Hexane (105)

g B/l	$\varphi_{18.7}$
0.0	21.2
540.4	207.4
570.0	226.5
647.1	272.1
653.4	275.4
662.8	285.2
666.0	287.3

B = $C_{10}H_{15}N$, Diethylaniline (26)

Wt. % B	φ_0	$\varphi_{76.5}$
0.00	11.32	105.2
9.97	13.22	
29.48	17.55	
30.00		127.6
49.92	22.13	138.2
69.56	26.17	141.1
89.96	27.78	138.0
100.00	26.05	127.7

$C_5H_{12}O$

Ethyl *n*-propyl ether

B = $C_7H_{14}O_2$, Isoamyl acetate (60)

Wt. % B	φ_{25}
0.00	294.7
88.84	144.9
92.58	138.6

$C_6H_4Br_3N$

2, 4, 6-Tribromoaniline

B = $C_7H_{14}O_2$, Isoamyl acetate (139)

M A/l B	φ_{25}
0.71	98.3

$C_6H_4ClNO_2$

o-Chloronitrobenzene

B = $C_{12}H_{11}N$, Diphenylamine (142)

M % B	φ_{60}
0.0	22.7
21.5	29.0
43.0	38.3
61.5	47.2
81.0	54.4
100.0	61.7

$C_6H_4Cl_3N$

2, 4, 6-Trichloroaniline

B = $C_7H_{14}O_2$, Iso (?) amyl acetate (139)

M A/l B	φ_{25}
0.71	101.5

C_6H_5Br

Bromobenzene

B = C_6H_5Cl, Chlorobenzene (78); *cf.* (55)

M % B	φ_{12}	φ_{64}
0.0	70.7	149.2
32.6	76.7	164.6
79.8	92.3	189.1
100.0	99.6	202.6

B = C_6H_6, Benzene (104); *cf.* (157)

°C	φ
0 Wt. % A	
0	109.6
10	131.9
20	153.4
30	177.3
40	198.7
50	226.0
60	255.0
70	279.1
80	303.5
22.57 Wt. % A	
0.1	101.8
8.6	118.0
19.9	140.4
30.3	162.0
40.6	185.2
50.2	207.1
60.4	230.3
70.5	253.2
50.24 Wt. % A	
0.1	91.2
10.2	108.1
20.3	125.8
30.4	144.2
40.1	163.3
51.4	184.5
60.7	203.6
70.2	223.8
74.75 Wt. % A	
0.1	79.8
9.8	93.1
11.0	94.3
19.4	106.3
30.3	123.4
40.1	139.2
49.9	155.3
60.1	172.1
70.5	190.3
100 Wt. % A	
0	66.0
10	78.0
20	89.5
30	102.2
40	114.7
50	126.0
60	139.1
70	153.5
80	165.6

B = C_7H_8, Toluene; for data at 20, 35, and 50°C, *v.* (157).

$C_6H_5Br_2N$

Dibromoaniline

B = $C_7H_{14}O_2$, Isoamyl acetate (139); for M A/l = 0.71, φ_{25} = 96.1 for 2, 4-A; = 100.3 for 2, 6-A.

C_6H_5Cl

Chlorobenzene

B = C_6H_6, Benzene (104)

°C	φ
25.16 Wt. % A	
0.3	108.0
10.5	128.1
20.2	147.9
30.2	169.3
39.8	190.8
50.2	215.5
60.4	239.2
70.5	260.3
79.9	282.9
50.54 Wt. % A	
0.2	103.3
11.1	123.2
20.2	140.0
29.6	158.4
40.6	181.2
49.1	200.2
60.5	223.2
70.4	245.1
79.9	264.4
74.61 Wt. % A	
0.2	98.4
10.3	116.3
20.5	133.2
30.0	150.2
40.0	168.8
49.6	187.2
60.1	207.8
70.0	227.2
80.0	244.1

B = C_6H_6O, Phenol (17)

Wt. % B	φ_{20}
0.00	130.2
4.93	121.2
9.78	112.6
21.73	89.1
30.43	72.8
38.90	59.8
49.90	45.1
58.15	36.4
71.41	24.6
81.45	18.01
100.00	9.06

B = C_7H_8, Toluene; for data at 20, 35 and 50°C, *v.* (157).

C_6H_5ClO

o-Chlorophenol

B = C_6H_7N, Aniline (17)

Wt. % A	φ_{10}	φ_{20}	φ_{30}
0.00	15.87	23.36	31.80
15.54	11.07	17.30	24.69
28.94	7.60	12.92	19.76
40.16	5.60	10.42	16.86

C_6H_5ClO.—(*Continued*)

B = C_6H_7N.—(*Continued*)

Wt. % A	φ_{10}	φ_{20}	φ_{30}
46.61	4.89	9.47	15.65
51.68	4.46	8.90	14.88
56.87	4.23	8.58	14.43
60.61	4.18	8.50	14.39
65.18	4.25	8.71	14.58
68.50	4.45	9.12	14.92
77.80	5.70	11.06	17.24
89.65	8.94	15.87	23.20
100.00	15.65	23.75	32.47
Wt. % A	φ_{40}	φ_{60}	φ_{80}
0.00	41.6	64.81	90.9
15.54	33.95	55.87	81.8
28.94	28.25	49.63	75.4
40.16	25.06	45.55	71.1
46.61	23.8	43.95	69.3
51.68	23.1	43.01	68.4
56.87	22.8	42.55	68.0
60.61	22.7	42.55	68.0
65.18	23.0	42.74	68.5
68.50	23.6	43.1	69.2
77.80	26.4	46.6	73.1
89.65	33.2	54.8	81.8
100.00	43.1	66.1	93.5

Wt. % A	φ_{110}	φ_{150}
0.00	141.0	224.2
15.54	128.0	200.8
28.94	118.8	185.5
40.16	112.9	176.1
46.61	111.0	173.3
51.68	110.0	171.8
56.87	109.6	170.9
60.61	109.6	170.9
65.18	110.2	171.2
68.50	111.0	172.1
77.80	114.6	174.8
89.65	122.0	178.9
100.00	131.6	183.2

Wt. % A	φ_{25} (140)	φ_{50} (140)
0.0	27.62	49.75
29.7	15.41	34.84
38.6	12.97	32.89
50.05	10.59	30.67
58.2	10.38	29.85
59.6	10.52	30.30
84.1	14.90	34.72
91.6	18.59	38.91
100.0	24.33	49.63

B = $C_6H_8N_2$, Phenylhydrazine (140)

Wt. % B	φ_{50}
0.0	49.63
14.75	28.49
36.0	13.97
46.5	12.09
49.3	12.22
75.0	14.38
100.0	21.83

B = $C_7H_{14}O_2$, Isoamyl acetate (136); for 80.2 Wt. % B, φ_{25} = 83.2.

B = $C_8H_{11}N$, Dimethylaniline (17)

Wt. % B	φ_0	φ_{10}	φ_{20}
0.00	9.27	15.65	23.75
9.86	6.89	12.50	21.10
16.19	6.36	11.88	20.08
19.13	6.32	11.85	20.00
24.59	6.49	12.05	20.45
29.50	6.94	12.56	21.32
39.60	8.40	14.88	24.15
47.51	10.16	17.61	27.03
59.35	14.79	23.26	32.79
72.29	22.99	31.90	41.15
85.33	33.11	42.74	53.79
100.00	49.38	60.42	72.20
Wt. % B	φ_{30}	φ_{40}	φ_{60}
0.00	32.47	43.10	66.09
9.86	29.33	40.82	63.37
16.19	28.21	40.41	62.77
19.13	28.21	40.49	62.93
24.59	28.53	41.67	63.98
29.50	29.33	43.39	65.62
39.60	32.36	47.96	70.32
47.51	35.84	52.23	74.74
59.35	42.55	60.24	82.64
72.29	52.91	70.92	92.76
85.33	67.89	80.45	106.4
100.00	85.47	97.66	125.3

Wt. % B	φ_{80}
0.00	93.5
9.86	91.3
16.19	91.2
19.13	91.7
24.59	93.3
29.50	95.2
39.60	100.5
47.51	105.4
59.35	113.9
72.29	124.4
85.33	136.8
100.00	152.0

B = C_9H_7N, Quinoline (17)

Wt. % B	φ_0	φ_{10}	φ_{20}
0.00	9.268	15.65	23.75
13.34	2.542	5.501	10.05
27.82	0.746	2.077	4.576
36.58	0.408	1.241	3.163
42.08	0.332	1.083	2.730
45.06	0.331	1.080	2.685
46.72	0.342	1.109	2.710
49.69	0.392	1.214	2.849
51.19	0.444	1.299	2.990
57.16	0.889	1.988	4.233
67.47	2.410	4.503	7.690
83.21	6.897	10.526	15.11
100.00	14.64	20.83	27.47
Wt. % B	φ_{30}	φ_{40}	φ_{60}
0.00	32.47	43.10	66.09
13.34	15.60	23.09	41.24
27.82	7.80	13.09	27.06
36.58	5.74	10.00	22.10
42.08	5.30	9.18	20.49
45.06	5.26	9.11	20.28
46.72	5.26	9.13	20.24
49.69	5.44	9.32	20.41

B = C_9H_7N.—(*Continued*)

Wt. % B	φ_{30}	φ_{40}	φ_{60}
51.19	5.58	9.55	20.66
57.16	6.94	11.16	22.73
67.47	10.98	15.75	27.82
83.21	20.53	26.95	42.02
100.00	34.01	41.93	59.84
Wt. % B	φ_{80}	φ_{110}	φ_{150}
0.00	93.5	131.6	183.2
13.34	62.5	99.3	153.8
27.82	45.35	79.0	131.8
36.58	39.06	70.9	121.6
42.08	37.04	68.1	117.6
45.06	36.04	66.9	116.3
46.72	35.91	66.6	115.6
49.69	36.04	66.4	115.2
51.19	36.23	66.4	115.1
57.61	38.54	68.4	116.7
67.47	45.01	75.0	122.7
83.21	59.77	88.6	134.2
100.00	80.00	107.5	150.2

B = $C_{13}H_{13}N$, Diphenylmethylamine (17)

Wt. % B	φ_0	φ_{10}	φ_{20}
0.00	9.27	15.65	23.75
10.38	9.07	14.97	22.73
20.66	8.83	14.31	21.79
31.24	8.55	13.70	20.88
42.42	8.22	13.04	19.92
49.48	8.00	12.58	19.23
61.65	7.51	11.83	18.08
74.10	6.85	11.01	16.81
86.17	6.18	10.15	15.46
100.00	5.45	9.13	13.79
Wt. % B	φ_{30}	φ_{40}	φ_{60}
0.00	32.47	43.10	66.09
10.38	32.11	41.84	63.49
20.66	29.76	40.16	61.05
31.24	28.49	38.46	58.47
42.42	27.14	36.36	55.71
49.48	26.29	35.09	54.05
61.65	24.81	32.89	50.89
74.10	23.23	30.77	47.39
86.17	21.58	28.57	43.96
100.00	19.49	26.04	40.32

Wt. % B	φ_{80}
0.00	93.5
10.38	89.3
20.66	84.7
31.24	80.8
42.42	76.9
49.48	74.2
61.65	70.4
74.10	66.7
86.17	62.8
100.00	57.6

C_6H_5ClO

m-Chlorophenol

B = C_6H_7N, Aniline (140)

Wt. % A	φ_{25}	φ_{50}
0.0	27.62	47.62
24.6	16.31	37.74
39.9	12.33	31.15
59.7	9.23	24.81

B = C_6H_7N.—(*Continued*)

Wt. % A	φ_{25}	φ_{50}
69.9	7.56	22.27
80.65	8.03	23.04
91.0	8.44	24.18
100.0	8.66	25.13

B = $C_7H_{14}O_2$, Isoamyl acetate (136); for 80.2 Wt. % B, φ_{25} = 80.4.

C_6H_5ClO

p-Chlorophenol

B = C_6H_7N, Aniline (140)

Wt. % B	φ_{25}	φ_{50}
0.0	27.62	49.7
9.7	22.12	45.2
29.8	14.18	32.6
49.8	8.93	23.9
58.2	7.63	22.2
62.8	7.09	20.8
70.1	6.37	19.5
77.8	5.85	18.6
84.6	5.81	18.6
92.2	5.95	19.5
100.0		20.0

B = $C_7H_{14}O_2$, Isoamyl acetate (136); for 80.2 Wt. % B, φ_{25} = 78.7.

$C_6H_5Cl_2N$

Dichloroaniline

B = $C_7H_{14}O_2$, Isoamyl acetate (139); for M A/l = 0.71, φ_{25} = 102.2 for 2, 4-A; = 89.3 for 2, 6-A.

C_6H_5F

Fluorobenzene

B = C_6H_6, Benzene (104)

°C	φ
25.78 Wt. % A	
0.2	116.2
10.6	139.4
21.1	158.9
30.4	182.5
40.3	202.9
49.9	228.0
59.8	255.0
70.5	280.7
79.5	302.6
49.76 Wt. % A	
0.3	121.6
9.7	142.3
19.8	161.9
30.5	186.2
40.2	206.2
50.1	230.6
60.1	257.0
69.8	279.9
80.2	305.0
75.04 Wt. % A	
0.2	127.4
10.4	150.2
19.8	166.5
30.1	189.4
40.0	208.7

B = C_6H_6.—(*Continued*)

°C	φ
75.04 Wt. % A	
50.0	232.2
60.3	257.9
70.7	282.6
79.8	304.8

C_6H_5I

Iodobenzene

B = C_6H_6, Benzene (104)

49.95 Wt. % A	
0.3	83.2
7.7	94.8
21.2	117.2
30.9	134.0
40.4	154.5
49.7	169.8
59.0	186.6
69.7	207.8
74.81 Wt. % A	
0.1	61.3
8.6	75.9
22.1	93.9
30.5	105.2
40.3	119.2
50.1	134.1
61.0	155.0
69.4	163.3

$C_6H_5I_2N$

Diiodoaniline

B = $C_7H_{14}O_2$, Isoamyl acetate (139); for M A/l = 0.71, φ_{25} = 89.3.

$C_6H_5NO_2$

Nitrobenzene

B = C_6H_6, Benzene (105)

g A/l	φ_{20}
0	151.8
952	67.5
1088	56.7
1155	53.0
1183	51.3
1193	50.4
1199	50.2
1201	50.0
1205	49.9
°C	φ
50 Wt. % B (102)	
0	76.9
25	114.3
40	142.8
55	166.3
70	192.0
Wt. % A	φ_{25} (99)
0.00	166.9
19.95	146.8
62.39	98.3
85.61	69.6
100.00	54.5

B = C_6H_6O, Phenol (17)

Wt. % A	φ_{20}
0.00	9.06
15.32	13.18

B = C_6H_6O.—(*Continued*)

Wt. % A	φ_{20}
29.97	18.5
41.36	23.9
50.27	28.3
62.04	35.15
72.59	40.6
81.88	45.3
91.16	49.0
95.84	50.6
100.00	51.8

B = C_6H_7N, Aniline (77)

M % A	φ_0	$\varphi_{24.2}$
0	9.79	39.8
10	13.53	
25	18.76	42.5
35	21.59	
45	24.89	46.5
50	25.80	
55	26.05	47.5
65	28.44	
75	29.47	49.3
90	30.95	49.3
100	31.11	48.9
M % A	φ_{65}	$\varphi_{95.8}$
0	56.2	72.2
25	61.8	79.6
45	64.1	80.1
55	64.8	80.1
75	64.1	79.5
90	64.0	78.0
100	64.2	77.4

B = $C_6H_{12}O_3$, Paraldehyde (105)

g B/l	φ_{20}
0.0	49.6
5.33	49.6
8.24	49.7
10.89	49.5
21.32	49.5
41.19	49.4
54.47	49.2
106.6	48.8
205.9	48.8
272.4	49.0

B = C_6H_{14}, Hexane (25)

°C	φ
0.0 Wt. % A	
16.35	310
18.55	313
20.00	314
21.40	319
23.22	323
24.2 Wt. % A	
16.90	237
18.45	241
20.02	245
21.42	250
23.15	253
36.5 Wt. % A	
17.42	182
17.50	195
17.70	195
18.55	196
20.50	203

B = C_6H_{14}.—(*Continued*)

°C	φ
36.5 Wt. % A	
22.85	210
25.10	216
44.6 Wt. % A	
18.87	165
19.08	173
20.62	187
22.02	185
23.42	189
25.00	194
50.7 Wt. % A	
19.40	133
20.50	143
21.60	154
23.70	161
25.20	165
54.2 Wt. % A	
19.92	126
20.12	131
21.70	145
23.25	150
25.40	155
64.4 Wt. % A	
18.30	116
18.75	120
20.95	125
22.90	129
24.92	134
70.8 Wt. % A	
14.8	100
15.8	104
18.5	109
19.9	111
21.6	114
23.3	116
25.1	120
79.6 Wt. % A	
15.09	84.7
16.67	87.0
18.44	89.3
20.51	91.7
22.73	95.2
24.30	97.1
100 Wt. % A	
13.5	44.1
18.0	48.3
23.0	52.9
28.0	57.8
32.0	61.3
35.0	64.5

B = C_7H_9N, *o*-Toluidine (78)

M % B	φ_{11}
0.00	40.9
33.34	37.9
50	32.8
66.67	27.6
100.00	16.7

B = $C_8H_{11}N$, Dimethylaniline (78)

M % B	φ_{11}	$\varphi_{77.5}$
0.00	..	148.3
25		163.5
32.13	50.0	

B = $C_8H_{11}N$.—(*Continued*)

M % B	φ_{11}	$\varphi_{77.5}$
50	53.4	179.7
67		191.1
68.72	56.1	
100.00	61.3	204.0

B = $C_8H_{11}N$, Ethylaniline (78)

Wt. % B	φ_{11}	$\varphi_{77.5}$
26.2		160.6
50	41.8	167.5
80		175.1
100	33.6	170.7

B = $C_{10}H_8$, Naphthalene (84, 85)

M % B	φ_{80}
0	125.8
20	123.8
30	122.6
50	119.6
70	117.2
80	115.7
90	114.2
100	112.9

B = $C_{10}H_{15}N$, Diethylaniline (78)

Wt. % B	φ_{11}
33.19	40.1
50	39.3
66.66	36.7
100.00	30.7

B = $C_{10}H_{20}O$, Menthol (132)

Wt. % B	$\varphi_{55.6}$	$\varphi_{74.6}$
0.00	95.2	127.7
11.33	99.9	133.5
36.12	74.0	101.8
51.11	53.8	87.0
68.61	47.5	83.7
86.73	26.8	64.8
100.00	15.9	40.5
Wt. % B	$\varphi_{82.2}$	φ_{99}
0.00	137.4	172.1
11.33	148.8	187.3
36.12	116.7	150.8
51.11	102.0	136.6
68.61	100.0	143.3
86.73	85.6	137.0
100.00	54.0	96.1

B = $C_{12}H_{18}O_8$, Diethyl diacetyltartrate (132)

Wt. % B	φ
67.30°C	
0.00	113.3
24.80	75.3
52.45	49.7
70.91	35.9
82.95	20.3
92.74	14.0
100.00	11.17
82.2°C	
0.00	137.4
24.80	100.5
52.45	70.6
70.91	50.5
82.95	32.4

$C_6H_5NO_2$.—(*Continued*)

B = $C_{12}H_{18}O_8$.—(*Continued*)

Wt. % B	φ
82.2°C	
92.74	24.6
100.00	18.17
99.0°C	
0.00	172.1
24.80	129.1
52.45	96.3
70.91	76.4
82.95	51.0
92.74	40.4
100.00	32.0

$C_6H_5NO_3$

o-Nitrophenol

B = C_6H_7N, Aniline [17, 154]

Wt. % A	φ_{20}	φ_{40}
0.00	31.8	41.6
10.88	33.6	43.1
22.36	34.9	44.3
32.77	35.6	45.0
42.00	35.7	45.1
51.28	35.4	44.8
60.52	34.7	44.0
68.32	33.9	43.0
77.11	32.6	41.4
85.04	31.0	39.8
91.49	29.5	38.3
100.00	27.4	36.3
Wt. % A	φ_{60}	φ_{80}
0.00	64.8	90.9
10.88	66.1	91.4
22.36	67.3	92.1
32.77	67.7	92.5
42.00	67.7	91.9
51.28	66.9	90.9
60.52	65.6	88.7
68.32	63.9	86.6
77.11	61.6	83.4
85.04	59.2	80.1
91.49	57.4	77.6
100.00	52.8	74.2

B = C_7H_9N, *p*-Toluidine [140]

Wt. % B	φ_{50}
0.0	37.3
20.4	46.5
64.7	54.5
100.0	55.6

B = C_9H_7N, Quinoline [17]

Wt. % B	φ_{20}	φ_{40}
0.00	27.40	36.30
4.46	29.32	35.03
8.82	25.32	33.84
13.24	24.45	32.69
17.59	23.70	31.74
22.44	22.96	30.77
32.96	21.77	29.33
41.80	21.19	28.82
50.84	21.37	28.86
58.39	22.25	29.63
69.31	24.24	31.65
78.57	26.52	34.15
89.20	29.75	37.59
100.00	34.01	41.93

B = C_9H_7N.—(*Continued*)

Wt. % B	φ_{60}	φ_{80}
0.00	54.8	74.2
4.46	53.4	72.9
8.82	52.4	71.8
13.24	51.3	71.1
17.59	50.3	70.4
22.44	49.4	69.4
32.96	47.8	68.0
41.80	47.1	67.3
50.84	47.1	67.4
58.39	48.0	68.0
69.31	50.1	69.6
78.57	52.7	71.9
89.20	55.9	75.7
100.00	59.8	80.0

B = $C_7H_{14}O_2$, Isoamyl acetate [136]; for 78.9 Wt. % B, φ_{25} = 95.1 for *o*-A; = 69.0 for *m*-A; = 63.9 for *p*-A.

C_6H_6

Benzene

B = C_6H_6O, Phenol [110]

Wt. % B	φ_{20}
0.00	159.0
6.04	146.4
9.84	138.1
20.1	115.6
32.40	88.8
42.09	71.4
53.02	52.3
63.65	37.85
74.11	26.24
83.20	18.69
100.00	9.06

B = $C_6H_{10}O_3$, Ethyl acetoacetate [35]

Wt. % B	φ_{25}
0.00	162.7
2.78	162.1
10.47	162.7
43.56	125.9
93.88	71.1
100.00	66.3

B = C_6H_{12}, Cyclohexane; for data at 20°C, *v.* [152-2].

B = $C_6H_{12}O_3$, Paraldehyde [105]

g B/l	φ_{20}
0.000	155.7
4.740	155.6
6.768	155.6
18.960	155.2
33.841	155.1
94.800	152.5
169.208	149.5
822.4	98.7
896.9	94.1
959.1	87.5
989.6	85.0
994.8	84.9

B = C_7H_8, Toluene [50]

Wt. % B	φ_{15}	φ_{20}	φ_{25}
0	142.1	154.1	165.0
25	160.3	171.2	179.9
50	158.5	167.5	176.7
75	152.7	164.7	174.2
100	159.5	170.6	180.8
Wt. % B	φ_{30}	φ_{35}	φ_{40}
0	177.9	189.8	203.3
25	190.5	200.8	211.9
50	188.3	199.2	210.1
75	185.5	197.6	208.3
100	192.3	202.8	214.6
Wt. % B	φ_{70}	φ_{80}	
0	284.9	305.8	
50	285.7		
100	287.4	314.5	

Wt. % B	φ_{25} [99]
0.00	166.9
8.44	168.4
33.42	172.7
69.41	179.2
89.01	180.2
100	184.8

50 Wt. % B [102]

°C	φ
0	124.4
25	179.5
40	216.6
55	249.3
70	284.3

B = C_7H_8O, *m*-Cresol [78]

M % B	φ_{12}	φ_{64}
0	137.9	270.8
25	80.9	189.5
50	34.0	144.9
75	12.15	93.9
100	3.37	54.8

B = C_8H_8O, Acetophenone [18, 116]

Wt. % B	φ_{16}
0.00	145.8
21.83	122.0
36.23	113.5
55.26	87.9
71.50	72.7
87.26	60.8
100.00	50.2
Wt. % B	φ_{25}
50	105.6
75	78.7
100	59.9

B = $C_8H_{14}O_3$, Ethyl ethylacetoacetate [35]

Wt. % B	φ_{25}
0.00	162.7
17.75	149.0
24.98	141.3
36.13	129.4
100.00	60.0

B = C_9H_7N, Quinoline [74]

0.00	165.0
15.83	128.1
23.33	122.0
32.44	106.9

B = C_9H_7N.—(*Continued*)

Wt. % B	φ_{25}
45.55	88.6
55.77	74.9
68.84	61.3
78.33	52.4
84.34	42.7
100.00	29.75

B = $C_9H_{10}O_2$, Ethyl benzoate [71]

Wt. % B	Vol. % B	φ_{25}
0.00	0.00	165.3
22.35	19.43	138.0
54.19	49.78	98.2
67.74	63.75	83.3
75.14	71.70	75.4
85.86	83.57	64.2
91.47	90.00	58.5
100.00	100.00	50.2

B = $C_{10}H_8$, Naphthalene [71]

0.00	0.0	165.3
8.11	7.3	152.3
17.16	15.2	137.7
22.97	20.6	129.8
28.82	25.8	121.0
34.10	30.8	114.1
37.69	33.9	109.0

For data at 10–31°C, *v.* [74.1].

B = $C_{10}H_{12}$, 1, 2, 3, 4-Tetrahydronaphthalene; for data at 20°C, *v.* [152.2].

B = $C_{10}H_{18}O_3$, Ethyl diethylacetoacetate [35]

Wt. % B	φ_{25}
0.00	162.7
3.65	160.3
14.16	146.7
49.52	101.3
68.19	75.7
100.00	35.8

B = $C_{12}H_{10}$, Diphenyl [71]

Wt. % B	Vol. % B	φ_{25}
0.00	0.0	165.3
18.08	15.8	131.8
30.57	27.3	110.9
53.03	48.9	77.0

B = $C_{14}H_{12}O_2$, Benzyl benzoate [14]

Wt. % B	φ_5	φ_{15}	φ_{25}
0.0	120.5	142.5	166.1
25.0	76.4	92.8	110.3
50.0	42.4	48.0	53.7
75.0	18.9	25.0	32.5
100.0	5.18	8.25	12.06
Wt. % B	φ_{40}	φ_{60}	φ_{80}
0.0	203.5	257.9	301.8
25.0	138.8	179.3	212.7
50.0	66.0	86.1	115.6
75.0	45.9	64.3	82.0
100.0	19.97	30.7	44.6
Wt. % B	φ_{90}	φ_{100}	
50.0	139.3		
100.0	52.3	60.4	

B = $C_{14}H_{12}O_2$.—(*Continued*)

Wt. % B	Vol. % B	φ_{25} (71)
0.0	0.0	165.4
38.71	33.08	83.6
65.60	59.91	43.45
79.17	74.84	27.90
90.73	88.44	18.25
95.88	94.78	14.53
100.00	100.00	11.83

B = $C_{16}H_{22}O_4$, *sec.*-Octyl hydrogen phthalate (36)

Wt. % B	φ_{25}
Racemic	
5.86	147.8
8.24	139.1
10.61	133.0
14.95	118.6
15.28	116.2
18.29	108.8
Dextro	
6.18	146.1
10.71	132.0
11.16	131.0
19.44	105.0
Levo	
19.29	106.2

C_6H_6BrN

Bromoaniline

B = $C_7H_{14}O_2$, Isoamyl acetate (139); for M A/l B = 0.71, φ_{25} = 103.5 for *o*-A; = 101.5 for *p*-A.

C_6H_6ClN

Chloroaniline

B = $C_7H_{14}O_2$, Isoamyl acetate (139); for M A/l B = 0.71, φ_{25} = 108.1 for *o*-A; = 105.0 for *m*-A; = 104.3 for *p*-A.

C_6H_6IN

Iodoaniline

B = $C_7H_{14}O_2$, Isoamyl acetate (139); for M A/l B = 0.71, φ_{25} = 98.9.

$C_6H_6N_2O_2$

Nitroaniline

B = $C_7H_{14}O_2$, Isoamyl acetate (139); for M A/l B = 0.71, φ_{25} = 98.8 for *o*-A; = 96.1 for *m*-A.

C_6H_6O

Phenol

B = C_6H_7N, Aniline (17)

Wt. % A	φ_{20}	φ_{125}
0.0	23.36	157.0
7.94	19.65	150.2
15.31	16.39	144.3

B = C_6H_7N.—(*Continued*)

Wt. % A	φ_{20}	φ_{125}
23.34	13.60	138.3
31.28	11.25	133.5
39.39	9.44	129.9
47.56	8.23	126.9
53.81	7.58	125.2
62.50	7.05	123.3
69.52	6.91	122.4
77.02	7.04	122.2
85.02	7.51	123.0
92.28	8.19	125.5
100.00	9.06	129.9
Wt. % A	φ_{30}	φ_{40}
0.00	31.8	41.6
7.58	27.3	36.5
15.96	28.0	27.7
23.33	19.7	27.7
31.65	16.8	24.4
39.14	14.6	21.7
47.14	13.0	19.6
54.00	12.0	18.35
61.84	11.2	17.45
69.28	11.02	17.15
76.86	11.25	17.45
84.80	11.99	18.32
92.50	13.02	19.6
100.00	14.10	21.0
Wt. % A	φ_{60}	φ_{80}
0.00	64.9	90.9
7.58	59.2	85.1
15.96	53.2	78.1
23.33	48.0	72.7
31.65	43.8	67.6
39.14	40.2	63.7
47.17	37.45	60.17
54.00	35.8	58.1
61.84	34.5	56.6
69.28	34.0	55.8
76.86	34.25	56.3
84.80	35.3	57.3
92.50	37.2	59.9
100.00	39.7	63.3

Wt. % A	φ_{35} (140)
0.00	36.6
35.1	18.6
51.4	15.3
67.9	13.9
79.7	14.4
100.0	18.0

M % A	φ_{23} (77)	$\varphi_{54.5}$ (77)	φ_{74} (77)
0	27.19	50.09	63.2
10	24.42	45.32	
25	20.25	38.45	52.6
32	17.75	36.15	50 2
40	15.92		
46	14.67	31.69	46.8
50	13.73	30.41	45.7
54	13.17	30.09	45.6
60	12.79	29.04	44.8
68	12.62	28.72	44.7
75	12.92	28.56	44.6
90	14.71	19.48	
100		30.60	45.6

B = $C_6H_8N_2$, Phenylhydrazine (140)

Wt. % B	φ_{50}
0.0	31.2
20.2	19.05
40.2	13.36
50.1	12.47
53.7	12.20
62.8	12.42
80.4	15.26
100.0	21.83

B = C_7H_9N, *p*-Toluidine (17)

Wt. % B	$\varphi_{39.9}$	$\varphi_{59.9}$	$\varphi_{79.8}$
0.00	20.88	39.7	63.25
10.24	18.59	36.0	58.4
19.81	16.91	33.4	55.4
28.89	15.95	32.2	53.8
37.30	15.90	32.1	53.8
44.91	16.63	33.2	55.4
53.75	18.42	35.6	58.6
61.43	20.75	39.0	62.5
70.14	24.45	43.8	68.1
79.33	29.83	50.4	75.6
90.15	38.00	60.6	87.0
100.00	48.08	71.5	99.4
Wt. % B	$\varphi_{99.9}$		φ_{125}
0.00	89.7		129.9
10.24	85.4		124.1
19.81	82.6		120.5
28.89	80.6		118.1
37.30	80.3		117.5
44.91	81.6		118.8
53.75	85.1		122.0
61.43	89.1		126.6
70.14	95.2		133.5
79.33	103.2		141.6
90.15	115.1		152.7
100.00	130.6		164.5
Wt. % B	φ_{150}		φ_{175}
0.00	168.9		203.3
13.66	161.8		196.9
20.57	158.7		195.3
23.75	157.5		194.2
34.31	156.0		192.3
43.69	157.2		193.4
54.39	161.6		197.2
61.76	165.8		201.6
65.58	168.4		204.1
76.89	178.6		213.7
83.38	184.8		219.3
100.00	203.7		236.4

Wt. % B	φ_{30} (140)
0.0	14.29
28.5	11.19
37.8	10.40
41.2	10.62
52.5	11.57
60.1	13.21

B = $C_7H_{14}O_2$, Isoamyl acetate (136)

Wt. % B	φ_{25}
84.7	90.5

B = $C_8H_{11}N$, Dimethylaniline (17)

Wt. % B	φ_{10}	φ_{20}
0.00	4.975	9.06
7.24	5.09	9.20
14.61	5.40	9.71
21.86	6.10	10.64
30.03	7.42	12.48
37.18	9.14	14.82
44.25	11.51	17.73
51.73	14.37	21.28
59.61	18.81	26.53
66.92	23.89	32.4
76.06	31.80	41.4
82.70	38.67	48.9
90.93	48.17	59.4
100.00	60.46	72.1
Wt. % B	$\varphi_{29.8}$	$\varphi_{40.2}$
0.00	14.10	21.1
6.81	14.58	21.8
13.92	15.43	22.7
21.17	16.6	24.1
29.01	18.8	26.9
36.05	21.3	29.9
43.86	25.4	35.0
50.81	30.0	39.8
58.54	35.3	45.8
67.29	43.2	54.35
75.40	51.6	63.7
83.39	61.4	73.8
92.07	74.0	86.3
100.00	85.2	97.9
Wt. % B	$\varphi_{59.9}$	φ_{80}
0.00	39.5	63.1
6.81	37.5	63.8
13.92	42.0	65.7
21.17	44.0	67.9
29.01	47.6	72.5
36.05	51.0	76.2
43.86	56.8	82.4
50.81	63.0	89.4
58.54	70.0	97.6
67.29	78.9	106.7
75.40	89.0	117.4
83.39	99.9	127.9
92.07	113.9	141.4
100.00	125.2	152.0
Wt. % B	φ_{126}	φ_{177}
0.00	129.9	204.1
7.24	131.4	214.1
14.61	134.2	217.4
21.86	137.4	220.8
30.03	142.2	226.2
37.18	147.1	231.5
44.25	153.1	237.0
51.73	159.5	243.9
59.61	168.4	251.3
66.92	177.0	259.1
76.06	188.3	268.8
82.70	196.9	276.2
90.93	207.5	284 1
100.00	216.9	293.3

C_6H_6O.—(*Continued*)

B = C_9H_7N, Quinoline (17)

Wt. % B	$\varphi_{9.8}$	$\varphi_{20.1}$
0.00	4.98	9.06
7.94	4.13	7.48
16.63	3.17	6.02
23.12	2.61	5.15
31.79	2.11	4.30
39.70	1.90	3.95
46.80	1.97	4.08
54.92	2.67	4.92
62.48	3.78	6.65
70.24	5.96	9.45
77.27	8.55	12.74
85.44	12.35	17.47
92.46	16.16	21.77
100.00	20.81	27.51
Wt. % B	$\varphi_{29.9}$	φ_{40}
0.00	14.10	21.01
8.21	11.85	18.12
16.51	9.90	15.24
24.25	8.50	13.37
32.08	7.44	11.92
40.11	6.76	11.06
47.69	6.96	11.27
55.38	8.19	12.58
62.86	10.36	15.15
70.18	13.47	18.74
78.04	17.85	23.84
85.08	22.25	28.95
92.23	27.43	34.66
100.00	39.97	41.95
Wt. % B	φ_{60}	φ_{80}
0.00	39.68	63.3
8.21	34.78	56.0
16.51	30.17	49.3
24.25	26.95	45.0
32.08	24.39	41.4
40.11	22.73	38.7
47.69	22.94	38.3
55.38	24.39	39.7
62.86	27.43	43.3
70.18	32.05	48.3
78.04	38.24	55.3
85.08	44.54	62.4
92.23	51.28	70.2
100.00	59.84	80.0
Wt. % B	φ_{125}	φ_{175}
0.00	129.9	203.3
7.94	119.5	194.9
16.63	108.9	184.5
23.12	103.2	175.4
31.79	94.8	165.0
39.70	89.4	158.2
46.80	86.4	154.1
54.92	86.6	153.4
62.48	89.2	153.8
70.24	94.0	155.8
77.27	101.2	160.8
85.44	111.0	170.1
92.46	119.5	177.3
100.00	127.2	182.8

B = $C_{10}H_9N$, α-Naphthylamine (140)

Wt. % B	φ_{30}	φ_{60}
0.0	14.29	31.2
52.0	4.02	11.7
56.5	3.72	11.11
79.1	3.09	9.17
92.5		8.85
100.0		8.93

B = $C_{12}H_{11}N$, Diphenylamine (17)

Wt. % B	φ_{30}	φ_{40}
0.00	14.10	21.10
7.96	13.78	20.64
15.41	13.48	20.1
23.40	13.07	19.5
31.16	12.64	18.9
40.35	12.08	18.15
46.57	11.61	17.6
53.44	11.14	16.9
61.40	10.56	16.1
69.13	9.97	15.3
76.71	9.33	14.4
84.82	8.58	13.5
92.13	7.96	12.6
100.00	7.37	11.8
Wt. % B	φ_{61}	φ_{81}
0.00	39.84	63.5
7.96	39.53	62.1
15.41	39.00	61.0
23.40	38.17	59.5
31.16	37.24	58.0
40.35	35.84	56.1
46.57	34.90	54.7
53.44	33.78	53.2
61.40	32.42	51.2
69.13	31.02	49.4
76.71	29.50	47.1
84.82	27.86	44.6
92.13	26.11	42.4
100.00	23.98	39.6

Wt. % B	φ_{50} (140)
0.0	31.2
32.4	26.15
58.9	22.93
79.5	20.0

B = $C_{12}H_{18}O_8$, Diethyl diacetyltartrate (132)

Wt. %B	$\varphi_{55.6}$	$\varphi_{67.3}$
0.0	39.9	57.4
30.87	34.7	49.6
55.45	19.5	30.0
68.37	12.0	18.9
84.38	10.26	16.3
94.58	8.24	14.3
100.00		11.17
Wt. % B	$\varphi_{82.2}$	φ_{99}
0.00	85.6	125.2
30.87	70.6	103.3
55.45	44.9	69.3
68.37	32.3	45.4
84.38	28.7	45.8
94.58	24.6	40.3
100.00	18.17	32.0

B = $C_{13}H_{13}N$, Diphenylmethylamine (17)

Wt. % B	$\varphi_{9.8}$	$\varphi_{20.1}$
0.00	4.98	9.06
10.70	5.33	9.54
21.21	5.71	10.05
32.90	6.20	10.69
43.13	6.66	11.30
51.58	7.09	11.83
63.08	7.66	12.53
72.31	8.16	13.09
82.82	8.73	13.70
90.52	9.12	13.99
95.08	9.17	14.12 (?)
100.00	9.12	13.85
Wt. % B	φ_{30}	φ_{40}
0.00	14.10	21.10
9.95	14.86	22.17
17.78	15.38	22.73
26.42	15.97	23.36
37.88	16.75	24.10
50.13	17.54	24.88
64.66	18.45	25.77
79.96	19.27	26.53
89.79	19.49	26.60
95.02	19.61	26.43
100.00	19.49	26.08
Wt. % B	φ_{60}	φ_{80}
0.00	39.53	63.09
9.95	40.08	63.05
17.78	40.49	63.09
26.42	40.90	62.93
37.88	41.41	62.74
50.13	41.75	62.38
64.66	42.11	61.58
79.96	42.19	60.61
89.79	41.67	59.45
95.02	41.07	58.55
100.00	40.32	57.64

C_6H_7N

Aniline

B = C_6H_{12}, Cyclohexane (25)

°C	φ
0 Wt. % A	
17	97.1
22	107.5
27	116.3
32	126.6
35	133.3
28.45 Wt. % A	
30.6	93.5
31.0	97.1
33.0	102.0
35.0	107.5
37.0	112.4
42.85 Wt. % A	
31.0	65.8
32.5	78.1
34.0	87.0
36.0	94.3
37.0	96.2
45.63 Wt. % A	
31.5	70.4
32.5	76.9
36.0	87.7

B = C_6H_{12}.—(*Continued*)

°C	φ
45.63 Wt. % A	
37.0	90.1
52.1 Wt. % A	
29.6	60.2
31.0	68.0
32.0	71.4
35.0	78.7
37.0	82.0
58.75 Wt. % A	
31.6	66.2
31.9	67.6
32.4	69.4
33.6	71.9
36.5	78.7
72.78 Wt. % A	
27.9	52.6
30.0	55.9
33.0	60.6
36.0	65.4
100 Wt. % A	
19.0	22.4
23.0	25.8
26.0	28.4
29.0	31.2
32.0	34.1
35.5	37.6

B = C_6H_8IN, Aniline hydroiodide (120)

Wt. % B	φ_{25}
0.00	27.5
2.04	25.2
4.21	22.2
9.04	17.8
14.05	13.5
18.00	11.4
20.48	9.73

B = C_7H_8, Toluene (86)

Wt. % B	φ_{85}	φ_{100}
25	168.6	200
50	226	256
75	293	330

B = C_7H_8O, *m*-Cresol (77)

M % B	φ_0	$\varphi_{34.1}$	φ_{64}
0	9.79	34.43	57.71
10	7.18	29.47	52.74
25	4.23	22.17	46.69
35	2.87	18.77	43.59
45	1.95	15.97	40.60
50	1.66	14.78	
55	1.49	13.98	37.85
65	1.22	12.80	36.37
75	1.12	12.27	35.53
90	1.09	12.14	34.60
100	1.19	12.34	35.90
M % B	$\varphi_{76.3}$		$\varphi_{95.9}$
0	64.60		77.11
25	54.92		69.08
45	49.42		63.49
55	47.53		60.93
75	45.51		59.37
90	45.32		58.93
100	45.85		58.99

B = C_7H_8O.—(*Continued*)

M % B	φ_{25} (144)
0.0	26.87
30.0	14.71
37.4	12.20
46.1	10.39
54.9	8.993
63.1	8.20
77.8	8.12
100.0	7.75

B = C_7H_8O, *p*-Cresol (140)

Wt. % B	φ_{25}	φ_{50}
0.0	27.62	49.7
30.0	14.39	34.1
53.6	9.35	25.2
62.7	8.06	23.5
79.5	6.94	21.6
90.0	6.90	21.2
100.0		21.6

B = $C_7H_{14}O_2$, Isoamyl acetate (139)

M A/l B	φ_{25}
0.71	113.1

B = $C_8H_{10}O$, Phenetole (17)

Wt. % B	φ_0	$\varphi_{9.9}$	$\varphi_{20.2}$
0.00	9.95	15.85	23.47
11.74	12.52	19.12	27.47
21.75	15.27	22.57	31.55
32.30	18.25	26.67	36.4
43.68	22.17	31.15	41.8
54.66	26.39	36.2	47.6
65.69	31.20	41.9	54.4
76.54	36.76	48.2	61.4
88.49	44.15	56.2	70.0
100.00	53.76	65.4	80.6

Wt. % B	$\varphi_{29.6}$	φ_{40}	φ_{60}
0.00	31.8	41.6	64.7
11.74	37.0	48.1	71.7
21.75	42.0	53.6	78.1
32.30	47.3	59.7	85.4
43.68	53.5	66.7	93.9
54.66	59.9	73.8	102.4
65.69	66.9	81.6	111.6
76.54	74.9	90.4	121.1
88.49	85.5	101.8	132.8
100.00	97.1	114.3	145.6

Wt. % B	φ_{80}
0.00	90.9
11.74	98.7
21.75	105.9
32.30	114.0
43.68	122.8
54.66	131.9
65.69	141.6
76.54	151.8
88.49	165.8
100.00	179.2

$C_6H_8N_2$
Phenylenediamine

B = $C_7H_{14}O_2$, Isoamyl acetate (139); for 0.71 M A/l B, φ_{25} = 99.1 for *m*-A; = 101.7 for *o*-A.

$C_6H_{10}O$
Mesityl oxide

B = $C_7H_{14}O_2$, Isoamyl acetate (31)

Wt. % B	φ_{25}
86.85	134.0
91.42	131.7

$C_6H_{10}O_3$
Ethyl acetoacetate

B = C_7H_9N, 2, 6-Lutidine (35)

Wt. % B	φ_{25}
0.00	112.5
10.9	107.6
32.63	98.2
52.01	87.3
88.55	69.5
100.00	65.1

$C_6H_{10}O_6$
Dimethyl *d*-tartrate

B = $C_6H_{10}O_6$, Dimethyl *dl*-tartrate (138)

Wt. % B	φ_{35}
0	7.52
50	7.63
100	7.69

C_6H_{14}
Hexane

B = $C_{10}H_{12}$, 1, 2, 3, 4-Tetrahydronaphthalene; for data at 20°C, *v.* (152.2).

B = $C_{10}H_{22}$, Decane (Diisoamyl) (16)

Wt. % B	Vol. % B, 25°C	φ_{25}	φ_{35}
0.00	0.00	304.0	353.6
35.50	33.17	228.9	269.2
62.28	59.82	181.0	216.3
100.00	100.00	120.8	149.2

Wt. % B	φ_{50}	φ_{65}
0.00	403.8	459.2
35.50	312.6	356.5
62.28	254.6	294.2
100.00	180.5	213.4

C_7H_7NO
Benzaldoxime

B = $C_7H_{14}O_2$, Isoamyl acetate (137); for M A/kg = 0.25, $\varphi_{24.7}$ = 119.4 for α-A; = 118.5 for β-A.

$C_7H_7NO_2$
m-Nitrotoluene

B = $C_{12}H_{18}O_8$, Diethyl diacetyltartrate (132)

Wt. % B	φ
t = 67.3°C	
0.00	115.3
25.92	72.2
49.32	49.4
67.74	30.9
80.77	21.8
92.18	13.2
100.00	11.17

B = $C_{12}H_{18}O_8$.—(*Continued*)

Wt. % B	φ
t = 82.2°C	
0.00	140.5
25.92	88.9
49.32	68.2
67.74	45.2
80.77	34.1
92.18	23.2
100.00	18.17
t = 99.0°C	
0.00	175.3
25.92	117.2
49.32	96.0
67.74	65.5
80.77	53.0
92.18	37.2
100.00	32.0

C_7H_8
Toluene

B = C_7H_8O, *m*-Cresol (78)

M % A	φ_{12}	φ_{64}
0	3.37	54.8
25	12.1	91.4
50	40.0	154.3
75	88.3	215.3
100	132.7	268.1

B = $C_9H_{10}O_2$, Ethyl benzoate (71); *cf.* (99)

Wt. % B	Vol. % B	φ_{25}
0.00	0.00	181.2
22.67	19.51	146.1
47.26	42.56	110.2
73.51	69.64	78.2
81.90	78.90	68.9
89.85	87.98	60.4
100.00	100.00	50.25

B = $C_{10}H_8$, Naphthalene (71)

0.0	0.0	181.0
5.73	4.8	171.1
13.72	11.8	156.4
20.12	17.4	145.6
27.31	24.1	133.9

For data at 10–31°C, *v.* (74.1).

B = $C_{12}H_{10}$, Diphenyl (71)

0.0	0.0	181.2
21.38	18.6	136.3
32.02	28.2	116.4
38.97	34.8	103.9

B = $C_{14}H_{12}O_2$, Benzyl benzoate (71)

0.00	0.00	181.2
41.69	35.58	84.5
63.11	56.93	49.6
81.09	76.82	27.7
89.60	86.94	19.7
95.41	94.16	15.0
100.00	100.00	11.83

B = $C_{10}H_{16}$ (?), Turpentine (99)

Wt. % B	φ_{25}
0.00	185.5
24.91	164.7

B = $C_{10}H_{16}$.—(*Continued*)

Wt. % B	φ_{25}
46.30	142.6
79.35	102.2
93.21	83.9
100.00	74.5

C_7H_8O
Benzyl alcohol

B = $C_7H_{14}O_2$, Isoamyl acetate (136)

Wt. % A	φ_{25}
17.2	96.6

C_7H_8O
m-Cresol

B = C_7H_9N, *o*-Toluidine (78)

M % B	φ_{12}	φ_{64}
0	3.37	54.8
25	2.97	53.2
50	3.92	58.4
75	8.12	74.9
100	17.22	101.7

M % A	φ_{25} (144)
0.0	27.43
33.0	12.41
49.6	8.92
66.2	7.23
75.1	7.27
100.0	7.75

B = $C_7H_{14}O_2$, Isoamyl acetate (136); for 17.2 Wt. % A, φ_{25} = 85.9 for *o*-A; = 85.7 for *m*-A; = 85.5 for *p*-A.

B = $C_8H_{11}N$, Dimethylaniline (78)

M % B	φ_9	φ_{64}	φ_{77}
0	2.47	54.8	71.7
25		68.0	
26.9	6.65		77.3
50	11.8	98.3	
65.1	21.3		
75			138.3
100	58.0	165.7	202.8

C_7H_8O
Anisole

B = $C_7H_{14}O_2$, Isoamyl acetate (136)

Wt. % A	φ_{25}
17.2	121.0

C_7H_9N
Toluidine

B = $C_7H_{14}O$, Isoamyl acetate (139); for M A/l B = 0.71, φ_{25} = 113.1 for *o*-A; = 113.4 for *m*- and *p*-A.

C_7H_9NO
o-Anisidine

B = $C_7H_{14}O_2$, Isoamyl acetate (139)

M A/l	φ_{25}
0.71	108.5

$C_7H_{14}O_2$

Isoamyl acetate

B = C_8H_6, Phenylacetylene (60)

Wt. % B	φ_{25}
0.00	126.6
7.43	126.4
100.00	113.3

B = $C_9H_7NO_3$, Piperonal oxime (137); for M B/kg = 0.25, $\varphi_{24.70}$ = 113.0 for α-B; = 109.2 for β-B.

B = C_8H_8, Phenylethylene (60)

Wt. % B	φ_{25}
0.00	126.6
4.70	125.9
100.00	90.2

(1)

8.39	124.6

B = C_8H_8O, Acetophenone (31)

4.31	124.7
8.28	122.3

B = $C_8H_8O_2$, Phenyl acetate (136)

20.7	107.3

B = $C_8H_8O_3$, Mandelic acid (36)

Wt. % *dl*-B	φ_{25}
6.12	95.4
7.64	90.9
9.86	84.2
12.88	74.9
Wt. % *l*-B	φ_{25}
4.72	100.1
7.93	89.4
8.55	87.0
11.39	78.1

B = $C_8H_9NO_2$, Anisaldoxime (137); for M B/kg = 0.25, $\varphi_{24.70}$ = 115.7 for α-B; = 114.6 for β-B.

B = C_8H_{10}, Phenylethane (60)

Wt. % B	φ_{25}
0.00	126.6
7.43	129.9
100.00	164.6

B = $C_8H_{10}O$, Methyl benzyl ether (136)

19.0	117.9

B = $C_8H_{10}O$, Phenetole (136)

19.0	117.0

B = $C_8H_{10}O$, Methyl tolyl ether (136); for 19.0 Wt. % B, φ_{25} = 115.5 for *o*-B; = 113.8 for *m*-B; = 116.3 for *p*-B.

B = $C_9H_6O_2$, Phenylpropiolic acid (60)

Wt. % B	φ_{25}
2.86	116.7
3.81	113.3
5.80	105.7
7.16	100.4

B = $C_9H_7BrO_2$, *cis*-Allo-1-bromocinnamic acid (137)

M B/kg	$\varphi_{24.70}$
0.25	115.2

B = $C_9H_7BrO_2$, *trans*-1-Bromocinnamic acid (137)

0.25	114.7

B = $C_9H_8O_2$, Cinnamic acid (60)

Wt. % B	φ_{25}
3.89	112.1
5.02	108.1

B = $C_9H_{10}O_2$, β-Phenylpropionic acid (60)

Wt. % B	φ_{25}
4.01	115.5
5.75	110.2

B = $C_9H_{10}O_2$, Benzyl acetate (136)

22.4	102.7

B = $C_9H_{10}O_3$, Ethyl hydroxybenzoate (136); for 24.2 Wt. % B, φ_{25} = 95.7 for *o*-B; = 63.0 for *m*-B.

B = $C_9H_{11}NO_2$, Ethyl *p*-aminobenzoate (139)

M B/l A	φ_{25}
0.71	88.5

B = $C_9H_{11}NO_2$, Ethyl anthranilate (139)

0.71	100.8

B = $C_9H_{14}O$, Phorone (31)

Wt. % B	φ_{25}
8.24	122.9
14.90	119.8

B = $C_{10}H_8O$, Naphthol (136); for 21.7 Wt. % B, φ_{25} = 64.6 for α-B; = 62.6 for β-B.

B = $C_{10}H_9N$, Naphthylamine (139); for 0.71 M B/l A, φ_{25} = 97.0 for α-B; 97.1 for β-B.

B = $C_{10}H_{10}O$, Benzylideneacetone (31)

Wt. % B	φ_{25}
5.12	117.8
9.12	110.5

B = $C_{10}H_{10}O_2$, Safrol (31)

16.45*	104.4
6.54	120.1
27.30	99.1

B = $C_{10}H_{12}O$, Benzylacetone (31)

3.65	123.4
7.92	120.1

B = $C_{10}H_{12}O_2$, Eugenol (31)

12.26	103.2
19.61	90.4
7.66*	108.7
14.51*	94.16

* *Iso*-B.

B = $C_{10}H_{15}NO$, Carvoxime (138); for 85.8 Wt. % B, φ_{25} = 90.2 for *d*-B; = 90.0 for *dl*-B; for 100 Wt. % B, φ_{95} = 21.01 for *d*-B; = 21.10 for *dl*-B.

B = $C_{12}H_{10}$, Diphenyl (31)

Wt. % B	φ_{25}
2.94	124.5
4.32	123.1

B = $C_{12}H_{11}N$, Diphenylamine (139)

M B/l A	φ_{25}
0.71	93.4

B = $C_{12}H_{12}O$, Cinnamylideneacetone (31)

Wt. % B	φ_{25}
1.50	125.6
2.47	123.7

B = $C_{13}H_{10}O$, Benzophenone (31)

5.74	117.5
6.48	115.6

B = $C_{13}H_{12}N_2$, Benzaldehyde phenylhydrazone (137); for 0.25 M B/kg, $\varphi_{24.70}$ = 113.8 for α-B; = 111.98 for β-B.

B = $C_{13}H_{12}O$, Diphenyl carbinol (136)

Wt. % B	φ_{25}
26.1	66.8

B = $C_{13}H_{20}O_2$, Menthyl propiolate (60)

5.37	114.9

B = $C_{14}H_{10}$, Diphenylacetylene (60)

4.17	120.3

B = $C_{14}H_{11}NO_2$, Benziloxime (137); for 0.25 M B/kg, $\varphi_{24.70}$ = 107.5 for α-B; = 106.3 for β-B.

B = $C_{14}H_{12}$, Diphenylethylene (60)

Wt. % B	φ_{25}
1.39	124.4
4.70	119.1

B = $C_{14}H_{14}$, Diphenylethane (60)

4.37	120.9
5.29	119.9

B = $C_{15}H_{12}O$, Benzylideneacetophenone (60)

4.00	117.9
5.45	114.7

B = $C_{15}H_{14}O$, Benzylacetophenone (31)

3.99	120.5
5.10	117.8

B = $C_{15}H_{14}O$, Diphenylacetone (31)

4.28	120.2
4.84	119.6

B = $C_{16}H_{14}$, Diphenylbutadiene (60)

Wt. % B	φ_{25}
2.06	120.8
2.44	121.1

B = $C_{16}H_{18}$, Diphenylbutane (60)

1.44	124.0
3.40	117.3

B = $C_{17}H_{14}O$, Dibenzylideneacetone (31)

2.15	121.1
2.76	119.4

B = $C_{17}H_{14}O$, Cinnamylideneacetophenone (31)

2.10	122.0
3.31	118.4

B = $C_{18}H_{26}O_3$, *l*-Menthyl *dl*-mandelate

Wt. % B	°C (138)	φ
14.0	25	90.1
100.0	85	15.3

B = *l*-Menthyl *l*-mandelate

14.0	25	92.2
100.0	85	15.8

B = $C_{18}H_{34}O_2$, Oleic acid (137)

M B/kg	$\varphi_{24.70}$
0.25	104.7

B = $C_{18}H_{34}O_2$, Elaidic acid (137)

0.25	102.7

B = $C_{19}H_{26}O_2$, Menthyl cinnamate (60)

Wt. % B	φ_{25}
1.20	124.4
6.08	111.6
18.48	82.5

B = $C_{19}H_{23}O_2$, Menthyl β-phenylpropionate (60)

5.88	114.6
9.38	108.5

B = $C_{20}H_{38}O_2$, Ethyl elaidate (137)

M B/kg	$\varphi_{24.70}$
0.25	109.3

B = $C_{20}H_{38}O_2$, Ethyl oleate (137)

0.25	108.0

B = $C_{21}H_{18}O$, Dicinnamylideneacetone (31)

Wt. % B	φ_{25}
0.89	124.4
0.01	123.9

C_8H_{10}

o-Xylene

B = C_8H_{10}, *m*-Xylene (78)

M % B	φ_{12}	φ_{64}
0.0	105.2	229.1
27.1	112.1	237.1
73.1	121.5	250.2
100.0	126.8	255.2

B = C_8H_{10}, *p*-Xylene (78)

M % B	φ_{12}	φ_{64}
0.0	105.2	229.2
18.5	110.0	234.6
68.1	118.7	249.0
100 0	125.5	257.1

C_8H_{10}

m-Xylene

B = C_8H_{10}, *p*-Xylene (78)

0.0	126.7	255.2
24.6	125.2	258.2
70.8	125.1	257.8
100.0	125.6	257.1

B = $C_8H_{11}N$, Dimethylaniline (78)

M % A	φ_{12}	φ_{64}
0 0	63.5	165.9
28.7	78.3	185.7
73.4	105.9	229.7
100 0	126.7	255.2

$C_8H_{10}O$

Phenetole

B = $C_{12}H_{10}O$, Phenyl ether (73)

M % B	φ_{25}
0.00	86.36
9.94	76.40
18.73	68.92
29.63	61.27
39.98	53.70
48.95	47.71
62.69	40.73
67.47	38.03
79.28	33.30
86.33	30.63
100.00	25.88

$C_9H_{10}O_2$

Ethyl benzoate

B = $C_{14}H_{12}O_2$, Benzyl benzoate (73)

0.00	49.65
10.37	42.17
19.77	36.37
30.94	30.78
40.59	26.74
49.46	23.22
60.55	20.21
70.27	17.56
75.25	16.37
84.51	14.50
95.35	12.44
100.00	11.74

$C_{10}H_8$

Naphthalene

B = $C_{10}H_{20}O$, *l*-Menthol (132)

Wt. % B	$\varphi_{82.2}$	$\varphi_{99.0}$
0.00	137.6	179.2
19.40	117.1	156.4
35.87	126.8	170.0
54.17	102.5	139.7

B = $C_{10}H_{20}O$.—(*Continued*)

Wt. % B	$\varphi_{82.2}$	$\varphi_{99.0}$
69.89	87.5	131.0
84 76	75.7	123.8
92.63	63.7	109.5
100.00	54.0	96.1

B = $C_{12}H_{18}O_8$, Diethyl diacetyltartrate (132)

Wt. % B	$\varphi_{82.2}$	φ_{99}
0.00	137.6	179.2
31.74	72.78	99.1
52.89	63.82	89.4
69.49	47.26	71.2
82.34	27.84	43.2
91.9	25.57	42.4
100.00	18.17	32.0

$C_{10}H_{12}O$

Anethole

B = $C_{10}H_{20}O$, Menthol (132)

Wt. % B	$\varphi_{55.6}$	$\varphi_{74.6}$
0.00	77.7	108.9
9.90	78.4	111.0
34.60	68.4	91.0
53.01	60.3	101.1
67.87	46.97	84.4
84.85	28.44	55.2
100.00	15.91	40.5
Wt. % B	$\varphi_{82.2}$	$\varphi_{99.0}$
0.00	123.2	163.4
9.90	125.2	166.4
34.60	116.7	151.5
53.01	111.0	164.2
67.87	102.0	148.2
84.85	69.83	109.3
100.00	54.05	96.1

$C_{10}H_{14}O_8$

Dimethyl diacetylracemate

B = $C_{10}H_{14}O_8$, Dimethyl diacetyltartrate (9)

Wt. % B	φ_{25}
0	16.52
10	16.76
40	16.17
60	16.17
90	16.76
100	16.12

$C_{12}H_{10}N_2$

Azobenzene

B = $C_{13}H_{11}N$, Benzylideneaniline (19)

B = $C_{14}H_{12}$, Stilbene (19)

B = $C_{14}H_{14}$, Dibenzyl (19)

$C_{13}H_{11}N$

Benzylideneaniline

B = $C_{13}H_{13}N$, Benzylaniline (19)

B = $C_{14}H_{12}$, Stilbene (19)

$C_{14}H_{12}$

Stilbene

B = $C_{14}H_{14}$, Dibenzyl (19)

THREE-COMPONENT SYSTEMS

CH_3NO

Formamide

B = C_2H_6O, Ethyl alcohol

C = $C_4H_{12}IN$, Tetramethylammonium iodide (63)

Wt. % B in (A + B)	φ_{15}	φ_{25}	φ_{35}
	0 M C/l		
25	29.51	38.80	48.40
50	40.19	51.57	63.29
75	56.79	70.82	85.18
	0.1 M C/l		
25	28.83	37.72	46.90
50	38.90	49.95	61.31
70	54.70	67.84	80.84
	0.25 M C/l		
25	27.48	36.19	44.88
50	37.51	47.94	58.58

C_3H_6O

Acetone

B = $C_4H_{10}O$, Ethyl ether

C = C_6H_6, Benzene (13)

φ_{10}	φ_{20}	φ_{30}
	100 Wt. % C	
131.9	154.7	178.7
	100 Wt. % B	
386.0	426.5	469.4
	100 Wt. % A	
278.8	309.6	342.3
49.39 Wt. % A; 20.54 Wt. % B; 30.07 Wt. % C		
252.8	286.1	318.0

C_4H_5NS

Allyl thiocyanate

B = C_6H_7N, Aniline

C = C_7H_8, Toluene (86)

M % B	φ_{85}	φ_{100}
	25 M % C	
0	296.7	324.7
7.5	227.3	251.9
15.0	149.2	165.3
22.5	83.54	96.15
30.0	43.25	58.79
37.5	32.08	44.95
39.0	34.17	47.78
52.5	78.80	99.6
67.5	137.7	167.8
75.0	168.6	199.6
	50 M % C	
0	315.5	350.9
5.0	274.0	304.9
15.0	156.0	179.2
20.0	114.7	140.4
24.0	100.8	127.4
25.0	94.7	120.3
26.0	103.5	127.9
30.0	124.8	152.0

B = C_6H_7N; C = C_7H_8.—(*Continued*)

M % B	φ_{85}	φ_{100}
	50 M % C	
35.0	153.4	182.5
45.0	204.9	235.8
50.0	226.2	255.8
	75 M % C	
0	333.3	357.1
2.5	312.5	352.1
7.5	251.3	284.9
10.0	227.3	264.6
12.0	216.9	251.3
12.5	212.8	248.8
13.0	222.2	257.1
15.0	234.2	268.1
17.5	246.9	279.3
20.0	293.3	330.0

C_6H_6

Benzene

B = C_6H_7N, Aniline

C = C_7H_8O, *m*-Cresol (76)

B = C_7H_8O, *m*-Cresol

C = $C_8H_{11}N$, Dimethylaniline (79)

Wt. % A	Wt. % B	η/η_{w_9}
	100	29.1
0.00	90.50	23.8
8.70	82.60	12.55
17.60	74.80	7.05
36.30	57.60	2.87
56 10	39.80	1.41
77.00	21.00	0.856
	81.40	18.4
8.75	74.00	9.8
17.70	66.90	5.85
36.50	51.60	2.50
56.40	35.40	1.34
77.50	18.30	0.86
	71.60	12.9
8.80	65.30	7.61
17.90	58.90	4.74
36.70	45.30	2.24
56.50	31.10	1.27
77.60	16.00	0.83
	51.90	6.05
8.90	47.50	4.08
18.10	42.60	2.94
46.90	27.60	1.34
78.00	11.30	0.796
	26.50	2.51
9.10	24.10	2.02
18.30	21.60	1.68
47.50	14.00	1.05
78.20	5.80	0.76
0.00	0.00	1.28

LITERATURE

(For a key to the periodicals see end of volume)

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VELOCITY OF VAPORIZATION (AND GAS EVOLUTION) AND OF CONDENSATION (AND GAS ABSORPTION)

A. C. EGERTON

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MATIÈRES

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EVAPORATION IN VACUO

GENERAL FORMULA

$m = \alpha p\,(M/2\pi RT)^{1/2}$ (28, 41); *see further* Vol. I, p. 91.

m = mass in grams vaporized per cm² per sec.

p = vapor pressure at T, °K.

M = gram-molecular weight.

R = gas constant.

$\alpha = 1 - \nu$, where ν is the fraction of molecules reflected without condensation ("accommodation coefficient").

EVAPORATION FROM HOT FILAMENTS

For more recent critical compilation, *v.* (83.5)

Substance	$\log_{10} m$ (for p in mm Hg and $\alpha = 1$)	Range, °K	Lit.
Carbon*.....	$14.19 - 47\,000/T$		
	$-1.25 \log T$	3 100–3 800	(1, 77)
Molybdenum.....	$17.11 - 38\,600/T$		
	$-1.76 \log T$	2 000–2 400	(46)
Platinum.....	$14.00 - 27\,800/T$		
	$-1.76 \log T$	1 680–2 000	(46)
Tungsten†.....	$9.42 - 45\,450/T$	2 000–3 000	(18, 19, 41, 83)
Calcium‡.....	$10.978 - 10\,350/T$	770–970	(59)

* *See* (1); α varies with adsorption layer.

† Zwikker gives $\log_{10} m = 11.92 - 48\,400/T - 0.368 \log_{10} T - 0.00016T$; Langmuir gives $\log_{10} m = 15.402 - 47\,440/T - 1.4 \log_{10} T$ (M. P. 3540°K); Forsythe in close agreement with Zwikker's equation; Fonda's value at 2825°K lies between those of Langmuir and of Zwikker. For small crystals m is 30 % greater than for large (18). In N_2, m is 6 % of the value *in vacuo*; 3.9 % in argon (18). Rosenhain and Ewen (63) found the following ratio of m for coarse and for fine crystals: Zn, 2.3; Ag, 1.2; Cu, 1.4.

‡ Formula deduced from vapor pressure formula given by Pilling for $\alpha = 1$; the measurements of p included allowance for value of α obtained by comparative measurements with Zn and Cd (59).

EVAPORATION THROUGH AN APERTURE

If the diameter of the aperture is ≥ 0.1 of the mean free path, m is the same as from a free surface, $\alpha = 1$. Measurements have been made by this method for Cd, Hg, K, Na, Pb, Zn and benzophenone (13, 35, 62, 73).

EVAPORATION OF SMALL DROPS (74, 75)

Spherical drop (*see* general formula for evaporation *in vacuo*).

For a drop of mercury resting on plane, $m = -1.11 \frac{dr}{dt} \times \rho$, where ρ is the density of mercury and $\frac{dr}{dt}$ is the rate of change of radius with time.

ACCOMMODATION COEFFICIENTS

VALUES OF α FOR SATURATED VAPORS

Substance	α	t, °C	Lit.
Hg (liquid).....	1.00 ± 0.01	60 to −30	(37, 74, 75)
Hg (solid).....	0.85	−64	(74, 75)
Cd (solid).....	0.98 ± 0.2	(*ca.* 200)	(4, 14)
Th, Ta, W.....	1.0	(*ca.* 2000)	(42)
Benzophenone.....	0.2 to 0.5		(73)

VALUES OF α FOR GASES ON VARIOUS SOLIDS (36, 43, 64)

Gas	Polished Pt*		Pt black at 20°C	W at 1500°K	Glass at 0°C
	°C	α			
H_2.....	−190	0.42	0.71	0.19	0.26
	0	0.26			
CO_2.....	20	0.86	0.96		
O_2.....	20	0.83	0.95		
N_2.....	20	0.87		0.60	
He.....	−100	0.49			
	+200	0.38			
A.....	30–260	0.85			
Ne.....		0.65			

* Soddy and Berry found same results for Pd as for Pt surface.

CONDENSATION IN VACUO

OBSERVED TEMPERATURE REGION FOR IRREVERSIBLE CONDENSATION

Substance	On glass, t, °C	Lit.	Substance	t, °C	Lit.
NH_4Cl.....	< −183	(39)	Cd on paraffin.....	−70	(9)
Hg*.....	−140 to −130	(39, 81)	Cd on mica	−80	(9)
			Cd on glass.....	−90	(81)
Zn*.....	−183 to −78	(39)	Vapor at 280°.....	−110	(16)
Cd*.....			Vapor at 365°.....	−50	(16)
Mg.....					

OBSERVED TEMPERATURE REGION FOR IRREVERSIBLE CONDENSATION.—(*Continued*)

Substance	On glass, t, °C	Lit.	Substance	On glass, t, °C	Lit.
Cu	350 to 575	(39)	Ag*	< 575	(39)
			I_2	−60	(39)

* *Cf.* (15, 44).

Substance (16); *cf.* (38, 44, 78)	Vapor pressure, mm Hg	t, °C	Latent heat of adsorption, g-cal/g
Cd on glass	0.008	−107	5200
	0.03	−86	
Cd on copper	0.008	−111	2940
	0.03	−83	
Cd on silver	0.008	−86	3540
	0.03	−66	
Hg on silver	0.0083	−120	2560
	0.033	−88	

Although vaporization occurs according to the cosine law (38, 81), and for Ag, Zn, Sb_2S_3, and S (40), condensation is directed in the case of Cd, Hg, Zn and As but not HgI_2 or S, *v.* (23, 71, 72, 75).

EVAPORATION IN STILL AIR AND OTHER GASES

THEORETICAL EQUATIONS (66)

For values of diffusion coefficients, *v.* p. 62.

From flush circular area:

$$V = 4r\Delta \log_e \frac{p - p_0}{p - p_s}$$

when p_s is small, $V = Kp_s/p$ [Dalton (11)]. V = rate of evaporation (volume per unit time), p_s = saturation pressure at surface of liquid, p_0 = pressure of vapor in gas at distance from surface, p = total gas pressure, r = radius of circular area, Δ = diffusion coefficient (50, 58, 66, 80).

From elliptical area (a and b = axes of ellipse) approximate formula:

$$V = 4\sqrt{ab}\Delta \log_e \frac{p - p_0}{p - p_s} \text{ (58, 60, 66).}$$

From circular vessels (surface distant h below rim):

$$V = 4(\sqrt{h^2 + r^2} - h)\,\Delta \log_e \frac{p - p_0}{p - p_s} \text{ (6, 47, 68, 69, 70, 80).}$$

From vertical tube (distance from upper end of tube to surface of liquid in the tube, greater than the diameter):

$$V = \frac{A\Delta}{h} \log_e \frac{p - p_0}{p - p_s}.$$

A = area of cross section of tube, h = distance from upper end to surface (48, 52, 69, 79).

From spherical drop:

$$V = 4\pi r\Delta \log_e \frac{p - p_0}{p - p_s} \text{ (65)}$$

or

$$m = 4\pi r\Delta \frac{Mp_s}{RT} \text{ (45)} \left(\text{for small values } \frac{p_s}{p}\right)$$

m = mass evaporated per unit time; M = mol. wt.; r = radius of sphere, *v.* (84, 85).

The references refer to experimental work on the subject; the formulae hold only under ideal conditions. The essential conditions are adequacy of rate of supply of heat to maintain temperature of the surface (48) and absence of disturbance of the atmosphere in the neighborhood of the evaporating liquid (50, 58).

EVAPORATION OF SMALL DROPS

I_2 in air: $dm/dt = 1.83 \times 10^{-6} r$ (r radius of drop; m = g cm^{-2} sec^{-1} (54, 84).

Hg in air: $dr/dt = 1.4 \times 10^{-10}$, cm/sec for drops 10^{-4} to 10^{-3} cm radius. [Evaporation of small drops is checked by oxidation of droplet, *v.* (51)].

H_2O: Evaporation of small drops less than 10^{-4} cm radius checked by absorption of gases other than hydrogen (24).

CHANGE IN RADIUS WITH TIME

Minutes	Air	H_2, 70%; Air, 30%
5	0.89×10^{-4} cm	0.99×10^{-4} cm
20	0.86×10^{-4} cm	0.90×10^{-4} cm
45	0.86×10^{-4} cm	0.74×10^{-4} cm

PLATINUM METALS IN AIR

Loss in weight, g/cm²/sec in air at atmospheric pressure (7)

t	Pt	Pt + 1% Ir	Pt + 2.5% Ir	Pt + 8% Rh
900	0	0	0	0
1000	2.2×10^{-7}	8.3×10^{-7}	1.6×10^{-6}	1.9×10^{-7}
1200	2.2×10^{-6}	3.3×10^{-6}	7.0×10^{-6}	1.5×10^{-6}

Crookes (10) found the following percentage loss of total weight at 1300°C in air but did not mention extent of surface: 8 hr, Ru, 25%; 22 hr, Ir, 7.3%; 30 hr, Pd, 0.745%; Pt, 0.245%; Rh, 0.131%. (In case of Ru and Ir oxidation occurred. Ir *in vacuo* at 1300°C lost 0.069% in 30 hr.)

EVAPORATION IN A CURRENT OF GAS

In steady horizontal wind (velocity W):

$$V = k\sqrt{W} \text{ and } V = \alpha r^{1.5}$$

k and α, constants (circular area of radius r, areas 250 m² to 10 cm² or in gentle draughts 25 m² to 1 cm²) (33, 68). For very large areas, *see* especially (21).

Numerous meteorological formulae connect evaporation with temperature, hygrometric and wind conditions (*see* annotated bibliography (49).

General form: $dE/dt = A(p_s - p_d) + B(p_s - p_d)W$ (Dalton-Weilermann).

E, fall of level due to evaporation in time, t; p_s, saturation pressure at temperature of surface; p_d, saturation pressure at dew point; W, wind velocity; A and B, constants, *v. also* (53).

Typical formula: $E_{mm} = 0.425\ (p_s - p_d)\ (1 + 0.805W)$ (Fitz-Gerald); W measured in km/hr (up to 20 km/hr). p in mm. *See* especially (5, 17, 61, 67).

Similar formulae are used for *chemical engineering* purposes; *e.g.*, evaporation from pans in still air: $M = 0.02\ (p_s - p_d)^{1.2}$ (29).

Evaporation from pans in air current:

$$M = (0.031 + 0.0135W)(p_s - p_d)\frac{p_0}{p_1}$$

M kg m^{-2}hr^{-1}; W = air velocity m/sec from 0.5 to 4 m/sec; p_0 = 760 mm and p_1 = barometric pressure; range 20 − 70°C (28.5, 29, 31).

Notes

Rate of evaporation of water approximately proportional to vapor pressure up to (B. P. − 15°) (3).

At 50°C evaporation of water in a current of air (W = 2.5 m/sec) is 2.8 times as rapid as in still air, and for W = 5 m/sec, 3.8 times (3).

Number of gram-molecules of a liquid evaporated per unit time and unit surface is proportional to vapor pressure, *v.* (26, 30); for evaporation of toluene, nitrobenzene, *m*-xylene, and chlorobenzene in wind tunnel, *v. also* (69).

Evaporation from large areas (lakes, etc.) about two-thirds evaporation from small pans.

Evaporation of sea water approximately 5% less than fresh water.

Evaporation of ocean approximately 820 mm *per annum* (34, 82).

Vapor Pressure by Streaming Method

$$\log_e \frac{p_s}{p_s - p} = \frac{\text{const.}}{\sqrt{W}}$$

where W is velocity of gas stream and p is partial pressure of vapor in gas.

Dependence of velocity of vaporization on pressure, temperature and nature of gas (27, 32). For measurements on Ag, Tl, Pb and Sn, *v.* (76).

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THE VELOCITY OF DISSOLVING OF CRYSTALS IN LIQUIDS

R. G. Van Name

The velocity constant K has usually the value given by equation I or II. As recorded in the tables it has the dimensions [cm min^{-1}] and is independent of the unit of concentration. In cases where it has been necessary to give the constant in the author's or arbitrary units, it is designated by $K_{\text{arb.}}$

For the case of simple solution in a solvent (reversible)

$$K = \frac{v}{S(C_s - C)} \frac{dC}{dt} = \frac{v}{S(t_2 - t_1)} \ln \frac{C_s - C_1}{C_s - C_2} \qquad \text{(I)}$$

in which v = volume in cm^3, t = time in min, S = surface of contact in cm^2, C = concentration at time t, C_s = concentration at saturation, and ln = $\log_e$.

For the case of solution by interaction with a dissolved reagent

$$K = -\frac{v}{SC} \frac{dC}{dt} = \frac{v}{St} \ln \frac{C_0}{C} \qquad \text{(II)}$$

in which C_0 and C are the concentrations of the reagent at time zero and time t, respectively; other symbols as in I.

Since K depends upon the intensity of the stirring and upon the form and dimensions of the apparatus, a quantitative comparison of the results of different investigators is usually impossible.

The velocities of dissolving of metals in acids are subject to various disturbing effects, such as passivity, period of induction, large influence of physical state and of traces of certain impurities, evolution of gas, etc., and are often not expressible by definite velocity constants. The results obtained are frequently too complicated and difficultly reproducible to justify their inclusion in the following tables. In the case of magnesium, however, the disturbing effects seem to be of minor importance.

La constante de vitesse K a ordinairement la valeur donnée par l'équation I ou II. Dans les tables elle a la dimension [cm min^{-1}] et elle est indépendante de l'unité de concentration. Dans les cas où il a été nécessaire de donner la constante dans les unités arbitraires de l'auteur, elle est désignée par $K_{\text{arb.}}$

Pour le cas d'une simple dissolution dans un solvant (reversible)

$$K = \frac{v}{S\,(C_s - C)} \frac{dC}{dt} = \frac{v}{S(t_2 - t_1)} \ln \frac{C_s - C_1}{C_s - C_2} \qquad \text{(I)}$$

où v = volume en cm^3, t = temps en min, S = surface de contact en cm^2, C = concentration au temps t, C_s = concentration à la saturation et ln = $\log_e$.

Pour le cas d'une dissolution par reaction avec un réactif dissout

$$K = -\frac{v}{SC} \frac{dC}{dt} = \frac{v}{St} \ln \frac{C_0}{C} \qquad \text{(II)}$$

où C_0 et C sont respectivement les concentrations du réactif au temps zéro et au temps t; pour les autre symboles comme en I.

Comme K dépend de l'intensité de l'agitation et de la forme et des dimensions de l'appareil, une comparaison quantitative des résultats obtenus par différents expérimentateurs est ordinairement impossible.

Les vitesses de dissolution des métaux dans les acides sont sujets à des effets perturbateurs variés, tels que: la passivité, la période d'induction, la grande influence de l'état physique et des traces de certaines impuretés, l'évolution du gaz, etc., et de la sorte ne peuvent souvent pas être exprimées par des constantes de vitesse définies. Les résultats obtenus sont fréquemment trop compliqués et difficilement reproductibles pour justifier leur publication dans les tables suivantes. Cependant, dans le cas du magnésium, les effets parasites paraissent être d'importance moindre.

Die Geschwindigkeitskonstante K hat gewöhnlich den nach Gleichung I oder II sich ergebenden Wert und wie aus den Tabellen folgt, besitzt sie die Dimension [cm min^{-1}] und ist von der Einheit der Konzentration unabhängig. In Fällen wo es nötig war die Konstante in den vom Autor gegebenen, oder in sonst willkürlichen, Einheiten anzuführen, wird sie mit $K_{arb.}$ bezeichnet.

Für den Fall der einfachen reversiblen Lösung in einem Lösungsmittel gilt

$$K = \frac{v}{S(C_s - C)} \frac{dC}{dt} = \frac{v}{S(t_2 - t_1)} \ln \frac{C_s - C_1}{C_s - C_2} \qquad (I)$$

wo v = Volumen in cm^3, t = Zeit in Minuten, S = Kontaktoberfläche in cm^2, C = Konzentration zur Zeit t, C_s = Sättigungskonzentration und ln = $\log_e$.

Für den Fall der Wechselwirkung mit einem gelösten Stoff, hat man

$$K = -\frac{v}{SC} \frac{dC}{dt} = \frac{v}{St} \ln \frac{C_0}{C} \qquad (II)$$

Es bedeutet, C_0 und C die Konzentration des reagierenden Bestandteiles zur Zeit Null bezw. zur Zeit t. Die anderen Zeichen sind die gleichen wie bei I.

Da K von der Rührgeschwindigkeit, der Form und der Dimension des verwendeten Apparates abhängt, ist ein quantitativer Vergleich der Ergebnisse der verschiedenen Beobachter meist nicht möglich.

Die Lösungsgeschwindigkeit der Metalle in Säuren unterliegt den verschiedenen störenden Einflüssen, wie Passivität und Induktionsdauer. Bedeutend ist der Einfluss des physikalischen Zustandes der Probe, der Spuren von Verunreinigungen, der Gasentwickelung, u.s.w. Dies alles ist nicht durch eine bestimmte Geschwindigkeitskonstante ausdrückbar. Die Ergebnisse sind häufig zu kompliziert und zu schwer reproduzierbar um in diese Tafeln aufgenommen zu werden. Beim Magnesium scheinen sich jedoch die störenden Einflüsse weniger bemerkbar zu machen.

Generalmente il valore della costante di velocità K è quello dedotto dalle equazioni I o II. Questa velocità, come è indicato nelle tabelle, ha le dimensioni di [cm min^{-1}] ed è indipendente dalla unità di concentrazione. Nei casi in cui si è dovuto dare la costante in unità arbitrarie, quelle adoperate dagli autori, essa è stata indicata con $K_{arb.}$

Nel caso che si tratti di semplice dissoluzione in un solvente (riversibile)

$$K = \frac{v}{S(C_s - C)} \frac{dC}{dt} = \frac{v}{S(t_2 - t_1)} \ln \frac{C_s - C_1}{C_s - C_2} \qquad (I)$$

nella quale v = volume in cm^3, t = tempo in minuti, S = superficie di contatto in cm^2, C = concentrazione al tempo t, C_s = concentrazione al punto di saturazione e ln = $\log_e$.

Nel caso di dissoluzione con reazione con una sostanza disciolta si ha:

$$K = -\frac{v}{SC} \frac{dC}{dt} = \frac{v}{St} \ln \frac{C_0}{C} \qquad (II)$$

nella quale C_0 e C rappresentano le concentrazioni della sostanza reagente al tempo 0 ed al tempo t, mentre gli altri simboli hanno lo stesso significato che nella I.

Poichè K dipende dalla intensità della agitazione, dalla forma e dalle dimensioni dell'apparecchio, è impossibile confrontare quantitativamente i risultati dei vari sperimentatori.

Le velocità di dissoluzione dei metalli negli acidi risentono molto della azione di varie cause perturbatrici, come ad esempio: passività, periodo di induzione, stato fisico, presenza di tracce di certe impurezze, svolgimento di gas, ecc., e perciò spesso non sono esprimibili con valori ben definiti delle costanti. Spesso i risultati ottenuti sono troppo complessi e difficili a riprodursi per poter essere compresi nelle tabelle che seguono. Nel caso del magnesio tuttavia sembra che le cause perturbatrici non abbiano molta importanza.

VELOCITY CONSTANTS

1. Salts in Water

Rotary stirring, 400 r.p.m.; exposed surface horizontal, below stirrer; 25°C (30)

Salt	C_s,* g/100 g H_2O	K, cm/min
KI	146.45	0.186
KBr	67.75	0.171
KCl	36.32	0.147
NaCl	35.92	0.105
TlCl	0.385	0.204†
TlBr	0.057	0.144†
$PbCl_2$	1.08	0.060†
$PbBr_2$	0.974	0.078†
$BaCl_2.2H_2O$	36.9	0.096
K_2SO_4	12.04	0.102
$K_4Fe(CN)_6.3H_2O$	32.0	0.048‡
$FeSO_4.7H_2O$	29.7	0.048
$NiSO_4.7H_2O$	39.6	0.033
$CoSO_4.7H_2O$	37.8	0.036
$ZnSO_4.7H_2O$	57.9	0.030
$MgSO_4.7H_2O$	38.3	0.030
$CuSO_4.5H_2O$	22.29	0.039
$CdSO_4.\frac{8}{3}H_2O$	77.0	0.021
$CaSO_4.2H_2O$	0.210	0.021§

* Calculated as anhydrous salt. ‡ ‖ to cleavage surface.
† Fused salt used. § Selenite, ‖ to face (010).

2. Salts in Water

Rotary stirring, 50 r.p.m.; whole crystal exposed (12)

Salt	C_s, g/100 g soln.	$K_{arb.}$, 4.8°C	C_s, g/100 g soln.	$K_{arb.}$, 30.1°C
K_2SO_4	7.82	0.027	11.43	0.071
$NaClO_3$	45.47	0.043	51.22	0.083
$K_2Cr_2O_7$	5.52	0.026	15.17	0.069

3. Metals in Dissolved Iodine (and Bromine)

Disk of metal 40 mm diameter, 0.6 mm thick, supported vertically, whole surface exposed. Rotary stirring, 240 r.p.m.; S = 2.60 cm^2, but velocity per unit area not accurately calculable on account of difference in stirring on the two sides of the disk. Aqueous solution of I_2 (resp. Br_2) in KI (resp. KBr); 25 ± 0.1°C (27)*.

Metal	Salt, mole/l, I_2 in KI	$K \times S$, cm^3/min	Metal	Salt, mole/l, I_2 in KI	$K \times S$, cm^3/min
Hg	0.6	8.81	Zn	1.2	9.64
Cd	0.6	8.69	Hg	2.4	10.48
Zn	0.6	8.64	Cu	2.4	9.98
Hg	1.2	9.55	Ag	2.4	9.93
Cd	1.2	9.56		Br_2 in KBr	
			Hg	3.3	12.27

* These and further results in original seem to show that these five metals dissolve in I_2 + KI with the same velocity, expressed in equivalents of metal dissolving.

4. Metals in Dissolved Iodine

Method as above: Disk 38.3 mm × 0.5 mm. $S = 2.36$ cm²; velocity per unit area not accurately calculable, (*cf.* 3); 25 ± 0.1°C (26).* 0.5 mole KI and 0.02 mole H_2SO_4 per l.

Metal	Cd	Fe	Ni	Co
$K \times S$, cm³/min	6.86	6.88	6.88	6.87

Cd in acid solutions of iodides

H_2SO_4, mole/l	0	0.02						
Iodide, mole/l	0.5				0.25			
Iodide	HI	LiI	NaI	KI	MgI_2	CaI_2	BaI_2	CdI_2
$K \times S$, cm³/min	6.45	6.41	6.56	6.86	6.25	6.23	6.45	6.82

* The results show that K is independent of the metal but varies to a marked extent with the nature of the other cation present.

5. Metals in Aqueous Ferric Sulfate, Ferric Chloride and Chromic Acid

Values of $K \times S$, cm³/min; method and dimensions of disk as in 4 (28)

Ferric sulfate (ferric alum)* 24.6 ± 0.1°C

H_2SO_4, mole/l	0.01	0.25	1.25	5.0
Zn	4.38			
Cd	4.12	4.15	3.54	1.76
Fe	3.95	3.92	3.37	1.74
Ni	3.80	3.75	3.27	1.71
Sn		3.96		1.72
Cu		3.74	3.30	1.71
Ag		1.67	1.63	1.24

Ferric chloride, 24.6 ± 0.1°C

HCl, mole/l	0.1	0.5
Cd	4.19	4.17
Fe	4.14	4.35
Cu	3.44	4.20

Chromic acid* (added as CrO_3), 25 ± 0.1°C

H_2SO_4, mole/l	0.25	1.25	5.0
Cd	7.02	5.32	2.67
Ni	irregular		2.67
Sn			2.74
Cu	6.95	5.34	2.72
Ag	4.28		1.22

* Velocities for different metals tend to become the same with increasing H_2SO_4 concn., probably because it increases the viscosity and thus retards diffusion.

6. Metals in Aqueous Ferric Sulfate (9)

18 ± 0.1°C; no stirring; dissolving surface vertical; $S = 22.5$ cm²

Metal	Cu	Fe	Cd	Sn
K, cm/min	0.0142	0.0138	0.0144	0.0137

The agreement between the different metals in spite of the low acidity (*see* 5) is probably due to the slowness of diffusion in the unstirred solutions.

7. Copper in Aqueous Ferric Chloride and Cupric Chloride

All solutions contained NH_4Cl, 3.7 to 4.7 mole/l. Variations in concentration of NH_4Cl were without effect on K when over 2.5 mole/l were present. Rotary stirring, 1500 r.p.m.; dissolving surface horizontal; $S = 34$ to 35.3 cm²; 25°C (2).

Salt	No. of exps.	Initial concentration, mole/l	Mean, K, cm/min
$FeCl_3$ alone	3	(0.186) (0.191) (0.290)	0.205
$CuCl_2$ alone	2	(0.166) (0.195)	0.205
$FeCl_3 + CuCl_2$	4	Various	0.204
		Mean of the 9 exps.	0.2044

8. Magnesium and Zinc in Aqueous Acids

Rotary stirring, 300 r.p.m.; value of S in doubt, but apparently 0.22 cm² in all experiments; 25°C. K_a = Ionization constant (22).

Solution, initial concn. in mole/l	$K \times S$, cm³/min*	K_a
Mg		
HCl, 0.1	1.12	
HCl, 0.1 + $MgCl_2$, 0.0671	1.25	
HCl, 0.1 + $MgCl_2$, 0.1341	1.31	
HAc (Acetic acid), 0.1	0.405	
HAc, 0.1 + $Mg(Ac)_2$, 0.1	0.366	
HAc, 0.1 + $Mg(Ac)_2$, 0.2	0.326	
HAc, 0.1 + $MgSO_4$, 0.2	0.416	
HAc, 0.1 + Na_2SO_4, 0.2	0.454	
HAc, 0.1 + NaAc, 0.2	0.441	
H_2SO_4, 0.05	1.15	
H_2SO_4, 0.05 + KCl, 0.1341	1.43	
H_2SO_4, 0.05 + KBr, 0.1341	1.64	
H_2SO_4, 0.05 + KI, 0.1341	1.48	
HCl, 0.02	1.27	
2,5-Dihydroxybenzoic acid	0.774	108×10^{-5}
2,4-Dihydroxybenzoic acid	0.518	52×10^{-5}
Tricarballylic acid, 0.02	0.493	22×10^{-5}
Acetic acid (HAc), 0.02	0.449	1.8×10^{-5}
Zn		
HCl, 0.1	0.133	After period of induction

* The value of K is here not wholly independent of the acid concentration, but for any given acid tends to be larger the higher the dilution.

9. Metals in Aqueous Hydrochloric Acid

After period of induction or adequate pretreatment with acid. (*a*) A plate of the metal with one surface exposed, attached eccentrically to stirrer stem, acts as blade of stirrer. Radius of path not given; 100 r.p.m.; 25°C. (*b*) Same apparatus and temp. Stirrer stationary.

(*a*)	Metal	Solution, initial conc. in mole/l: HCl	Salt	K, cm/min	Lit.
	Al*	0.5		0.0025	(8)
		1.0		0.0037	
		1.5		0.026	
		2.0		0.057	
		3.0		0.088	
		4.0		0.123	
		1.0	$AlCl_3$, 0.33	0.044	
		2.0	$AlCl_3$, 1.0	0.064	
		1.0	KCl, 1.0	0.0078	
	Zn†	2.0		0.10	(7)
	Mg‡	0.125		0.41	(5)
(*b*)	Mg§	0.0625		0.20	(6)
		0.125		0.27	
		0.25		0.32	

* Cut from rolled bar. † Kahlbaum. ‡ Sheet metal, Kahlbaum. § A different sample of Mg from the above, not rolled.

10. PbS, ZnS and Related Minerals in Dilute Sulfuric Acid

Material, screened fragments of uniform size. No stirring. Velocities were proportional to concentration of acid between 0.0125 and 1.25% H_2SO_4. The relative values of the velocity constant tabulated below were the same at all temperatures between 0 and 50° (15, 16).

Mineral	Locality	$K_{arb.}$
Galena (PbS, about 98%)	Clausthal	1.00
Sphalerite (ZnS, about 99%)	Spain	3.2
Sphalerite (Pb, 11.4%; Fe, 3.6%)	Clausthal	6.3

10.—(*Continued*)

Mineral	Locality	$K_{arb.}$
Sphalerite (Pb, 14.9%; Fe, 3.5%; SiO_2, 11%)	Bensberg	11.1
Christophite (ferriferous ZnS; Fe, 16%; SiO_2, 19%)	Breitenbrunn	14.0

11. Mineral Carbonates in Acids

Material, except in cases of malachite and marble, large crystals. Single exposed surface vertical. Stirring by gas evolved only; 15°C (19, 20).

Mineral	Acid	$K_{arb.}$	Remarks
Iceland spar ($CaCO_3$)	HCl, HNO_3 or HI	1.00	Cleavage face. Velocity with HBr *ca.* 40% higher
Aragonite ($CaCO_3$)	HCl or HNO_3	0.48	Face (010)
Dolomite ($CaCO_3.MgCO_3$)	HCl or HNO_3	0.025	Face not specified
Witherite ($BaCO_3$)	HCl or HNO_3	1.28	Face not specified
Smithsonite ($ZnCO_3$)	HCl or HNO_3	0.087	Face not specified
Cerussite ($PbCO_3$)	HNO_3	0.76	Face (010)
Azurite [$2CuCO_3.Cu(OH)_2$]	HCl or HNO_3	0.33	Face not specified
Malachite [$CuCO_3.Cu(OH)_2$]	HCl or HNO_3	0.23	Massive
Marble ($CaCO_3$)	HCl or HNO_3	1.7	Massive

12. Copper in Aqueous Ammonia

Reaction autocatalytic, accelerated by dissolved copper. $K = \frac{v}{S(C+\alpha)}\frac{dC}{dt} = \frac{v}{S(t_2-t_1)} \ln \frac{C_2+\alpha}{C_1+\alpha}$ in which C = concentration of dissolved copper. $\alpha = \frac{K_0}{K}$, $K_0 = \left(\frac{v}{S}\frac{dC}{dt}\right)_{C=0}$, the initial velocity. For a given concentration of dissolved oxygen K_0 and α are constants. K_0 is approximately proportional to the square root of the oxygen concentration; K is practically independent of it. The validity of this equation ends abruptly with the formation of an oxide coating on the metal, due to accumulation of OH^- ions produced by the reaction. This stage is deferred by a higher concentration of ammonia, and also by ammonium salts.

Mean values of K for various constant concentrations of ammonia in solutions kept saturated with air. Two copper plates 1.5 × 1.3 cm describe in liquid a circular path 2 cm in radius, 1120 r.p.m.; S = 7.6 to 8.6 cm²; 24.8°C (32).

$K_0 = 13.6 \times 10^{-4}$		$\alpha = 0.0020$
NH_3, mole/l	NH_4 salt, mole/l	K,* cm/min
1.047	0	0.640
1.921	0	0.703
3.963	0	0.653
1.047	$(NH_4)_2SO_4$, 0.01	0.710
1.088	$(NH_4)_2SO_4$, 0.05	0.680
1.080	$(NH_4)_2SO_4$, 0.1	0.671
1.080	NH_4NO_3, 0.1	0.681
1.080	NH_4Cl, 0.1	0.691
		Mean 0.679

* The results show that within these limits K is independent of the concentration of free ammonia and of ammonium salts.

13. Silver in Aqueous Potassium Cyanide

For constant concentration of dissolved oxygen $K = \frac{v}{St}\left[m(C_0 - C) + \log_{10}\frac{C_0}{C}\right]$ in which C = concn. of KCN, C_0 = initial concn., m = a constant = $0.4343\frac{k_2}{k_1}$ (k_2 = velocity constant of the diffusion of cyanide. k_1 = velocity constant of the chemical reaction at interface). The validity of this equation is ultimately disturbed by OH^- ions produced by the reaction itself, and the sooner the smaller the value of C_0.

Mean values of K and m for various initial concentrations of KCN for solutions kept saturated with air.* Stirring like last; 600 r.p.m.; two silver plates 1.5 × 1.2 cm; S = 7.3 to 8.7 cm², 25°C (33).

C_0, mole/l	m	K, cm/min	C_0, mole/l	m	K, cm/min
0.1480	135	0.226	0.0042	140	0.231
0.0632	140	0.230	0.0022	150	0.217
0.0316	145	0.231	0.0011	150	0.209
0.0158	155	0.222			
0.0079	140	0.225		Mean 144.4	0.224

* In solutions saturated with pure oxygen the velocity of dissolving, $-\frac{dC_{Ag}}{dt}$, was 2.5 times larger, indicating approximate proportionality with $[O_2]^{1/2}$. K was also increased but in a somewhat smaller ratio.

14. Zinc in HCl Dissolved in Alcohols and in Acetone

A thin rod of zinc mechanically raised and lowered in liquid 72 times per minute. S = 2.78 cm²; organic solvents anhydrous, and contained initially 0.5 mole/l of HCl; presence of a small amount of H_2O in CH_3OH, C_2H_5OH and $(CH_3)_2CO$ lowered velocity; 20°C (34).

HCl in	Methyl alc.	Ethyl alc.	Amyl alc.	Acetone	H_2O
K, cm/min	0.37	0.17	<0.01	0.42	0.14

TEMPERATURE COEFFICIENTS

M designates mechanical stirring; G, stirring by gas evolved by reaction; O, no stirring

Reaction and stirring		Comparable velocities at two temperatures		$\frac{K_{t+10°}}{K_t}$	Lit.
Benzoic acid in H_2O,	M	$(1.587)_{1.5}$	$(2.851)_{17.5}$	1.442	(31)
		$(2.851)_{17.5}$	$(4.524)_{31}$	1.408	
		$(4.524)_{31}$	$(5.756)_{40}$	1.307	
		$(5.756)_{40}$	$(9.946)_{60}$	1.314	
Cd in I_2 + KI,	M	$(3.72)_0$	$(5.87)_{15}$	1.356	(25)
		$(5.87)_{15}$	$(7.62)_{25}$	1.298	
		$(7.62)_{25}$	$(9.55)_{35}$	1.253	
		$(9.55)_{35}$	$(11.81)_{45}$	1.237	
		$(11.81)_{45}$	$(14.26)_{55}$	1.207	
		$(14.26)_{55}$	$(16.93)_{65}$	1.187	
K_2SO_4 in H_2O,	M	$(0.027)_{4.8}$	$(0.071)_{30.1}$	1.47	(12)
		$(0.071)_{30.1}$	$(0.166)_{68.9}$	1.25	
$K_2Cr_2O_7$ in H_2O,	M	$(0.026)_{4.8}$	$(0.073)_{35.3}$	1.40	
$NaClO_3$ in H_2O,	M	$(0.043)_{4.8}$	$(0.083)_{30.1}$	1.30	
		$(0.183)_{35.1}$	$(0.261)_{44.7}$	1.45	
Benzoic acid in H_2O,	M	$(2.30)_{20}$	$(3.35)_{30}$	1.5	(4)
$Mg(OH)_2$ in benzoic acid,	M	$(1.55)_{20}$	$(2.35)_{30}$	1.5	
$Mg(OH)_2$ in HCl,	M	$(8.1)_{20}$	$(12.2)_{30}$	1 5	
Cu in $FeCl_3$ or $CuCl_2$,	M	$(0.1508)_{15}$	$(0.2044)_{25}$	1.36	(2)
Cu in $Fe_2(SO_4)_3$,	O	$(0.031)_0$	$(0.045)_{11}$	1.40	(9)
		$(0.045)_{11}$	$(0.054)_{18}$	1.30	
		$(0.054)_{18}$	$(0.070)_{25}$	1.45	
Fe in $Fe_2(SO_4)_3$,	O	$(0.055)_{18}$	$(0.074)_{25}$	1.53	
Cd in $Fe_2(SO_4)_3$,	O	$(0.037)_0$	$(0.048)_{11}$	1.27	
		$(0.048)_{11}$	$(0.062)_{18}$	1.44	
		$(0.062)_{18}$	$(0.076)_{25}$	1.34	
Sn in $Fe_2(SO_4)_3$,	O	$(0.030)_0$	$(0.050)_{18}$	1.33	
		$(0.050)_{18}$	$(0.062)_{25}$	1.36	
Cu in $K_2Cr_2O_7$ + H_2SO_4,	M	$(8.15)_{21}$	$(10.38)_{31}$	1.27*	(29)
		$(10.38)_{31}$	$(13.03)_{41}$	1.26	
Cu in NH_4OH(air-satd.),	M	$(2.094)_{19.8}$	$(2.263)_{24.8}$	1.17	(32)
		$(2.263)_{24.8}$	$(2.588)_{34.8}$	1.14	

TEMPERATURE COEFFICIENTS.—(*Continued*)

Reaction and stirring	Comparable velocities at two temperatures		$\frac{K_{t+10^\circ}}{K_t}$	Lit.
Ag in KCN(air-satd.), M	$(2.51)_{15}$	$(2.82)_{25}$	1.13	(33)
	$(2.82)_{25}$	$(3.26)_{35}$	1.16	
	$(3.26)_{35}$	$(3.84)_{45}$	1.18	
Mg in HCl, G	$(2054)_0$	$(3059)_{25}$	1.17†	(6)
	$(3059)_{25}$	$(5564)_{50}$	1.27	
	$(1.00)_{50}$	$(1.51)_{75}$	1.2†	(3)
Al in HCl (2*N*), M	$(55)_0$	$(1396)_{45}$	2.05	(8)
Al in HCl (3*N*), M	$(248)_0$	$(982)_{25}$	1.73	
Fe in HCl, G	$(2.5)_{50}$	$(5.8)_{61.4}$	2.1	(18)
	$(5.8)_{61.4}$	$(19)_{78.4}$	2.0	
Fe in H_2SO_4, G	$(1.83)_{2.3}$	$(11.5)_{28.7}$	2.0	(10)
	$(11.5)_{28.7}$	$(26.2)_{45}$	1.7	
	$(26.2)_{45}$	$(63.1)_{58.5}$	1.9	
Iceland spar in HCl, G	$(0.044)_0$	$(0.095)_{15}$	1.67	(21)
	$(0.095)_{15}$	$(0.251)_{35}$	1.62	
	$(0.251)_{35}$	$(0.565)_{55}$	1.50	
Witherite in HCl, G	$(0.122)_{15}$	$(0.406)_{35}$	1.8	(20)
Azurite in HCl, G	$(0.031)_{15}$	$(0.062)_{35}$	1.4	
Dolomite in HCl, G	$(0.0024)_{15}$	$(0.0046)_{35}$	1.38	
Smithsonite in HCl, G	$(0.0083)_{15}$	$(0.0142)_{35}$	1.31	
Malachite in HCl, G	$(0.022)_{15}$	$(0.037)_{35}$	1.30	
PbS, ZnS (minerals) in dilute H_2SO_4, O	Range 0 to 80° (8 temps.), coefficient constant		1.54	(15)
Cu in benzaldehyde dissolved in toluene, 10% by Vol.	$(52.8)_{40}$	$(72.2)_{50}$	1.36	(17)
O	$(72.2)_{50}$	$(106)_{60}$	1.46	
	$(106)_{60}$	$(153)_{70}$	1.44	
	$(153)_{70}$	$(220)_{80}$	1.43	
	$(220)_{80}$	$(320)_{90}$	1.45	
	$(320)_{90}$	$(455)_{100}$	1.42	

* Two other determinations at different concentrations but same temperature range gave 1.29 and 1.30, respectively.

† Practically the same value was obtained also in mechanically stirred solutions.

RELATIVE VELOCITIES FOR DIFFERENT CRYSTAL FACES

In the case of simple (reversible) solution in a solvent a difference in the observed velocities of dissolving of two faces of the same crystal may be partly or wholly due to a difference in the solubilities (C_s) of the two faces, rather than in their velocity constants K. In some cases the evidence decidedly favors this explanation, notably when the velocities for the two faces differ appreciably only when the solution is nearly saturated.

Sodium Chloride in Water and in Various Solutions

Dissolving face vertical. No stirring. 25°C (14). The table summarizes results for other faces compared with results for cube. Owing to influence of convection currents, K for cube increased linearly with $(C_s - C)$. A face other than the cube gave a different value of K and a different rate of increase if C_s for cube was used in the calculations, but complete agreement was obtained by assuming C_s for the second face to differ by the percentage amount, Δ. Differences were appreciable only in solutions very nearly saturated, and disappeared entirely if saturation was 90% or less. The author concludes that K has the same value within error of experiment for all faces of NaCl, and that Δ represents actual percentage differences in the solubility of the given face from that of the cube.

	Various faces in pure NaCl solutions, Δ%	With formamide, 150 g/l, Δ%
Octahedron	+0.04	−0.4
Tetrahexahedron (310)	±0.00	±0.0

Sodium Chloride.—(*Continued*)

	Various faces in pure NaCl solutions Δ%	With formamide, 150 g/l, Δ%
Tetrahedron (320)	−0.18	
Dodecahedron	−0.18	−0.4
Trisoctahedron (221)	±0.00	−0.3
Hexoctahedron (321)	−0.18	−0.2
Trapezohedron (211)	−0.18	−0.2

Octahedron in NaCl solutions containing

Urea		Formamide		KNO_3	
g/l	Δ%	g/l	Δ%	g/l	Δ%
0	±0.04	23	±0.0	40	±0.0
50	±0.00	53	±0.0	80	±0.0
96	−0.10	80	−0.2	120	+0.1
130	−0.12	110	−0.3	160	+0.1
180	−0.17	150	−0.4	200	±0.0
230	−0.34	188	−0.4		
280	−0.42				

Gypsum ($CaSO_4.2H_2O$) in Water

C_s = 2.094 g/l (anhyd. salt). C at all times $<0.16C_s$; rotary stirring; relative velocities for surfaces cut parallel to pinacoid (010), prism (110) and pyramid (111); 25° (23).

V_{010}: V_{110}: V_{111} = 1.00: 1.76: 1.88

Wagner (30) finds at 25° V_{010}: V_{111} = 1.00: 156.

$CuSO_4.5H_2O$ in Water

C_s = 228.0 g/l (anhydrous salt); C at start = $0.9175C_s$; method like last; 24.9° (24).

V_{110}: $V_{1\bar{1}0}$ = 1.00:1.27

Tartaric Acid and Salts in Water

Relative velocities. Two unlike faces acted upon simultaneously. Exposed surfaces vertical; no stirring; *ca.* 20° (11)

Tartaric acid in water	(100)	(10$\bar{1}$)	(110)	(1$\bar{1}$0)	(101)	(011)	(001)
C = 875 g/l	1.00	1.29	1.49	1.55	1.63	1.68	1.76

$CuSO_4.5H_2O$ in water	(1$\bar{0}$0)	(1$\bar{1}$0)	(111)	(010)	(110)
C = 168 g/l (anhyd. salt)	1.00	1.37	1.28	1.18	1.12

$K_4Fe(CN)_6.3H_2O$ in water	(010)	(110)	(011)
C = 389 g/l (anhyd. salt)	1.00	1.79	1.86

$NaNO_3$ in Water

C = 485.5 g/l; no stirring; 25° (13)

Rhombohedron (10$\bar{1}$0)	Rhombohedron ($\bar{1}$2$\bar{1}$0)	Base (0001)
V = 11.8	10.7	10.8 mg/cm² min⁻¹

$MgSO_4.7H_2O$ in Water

C = 331 g/l (anhyd. salt); no stirring (13)

Base (001)	Pinacoid (010)	Prism (110)	Sphenoid (111)
V = 3.7	3.5	3.5	3.7mg/cm²min⁻¹

Quartz in Hydrofluoric Acid

Sol. I: HF = 97.18 g/l; Sol. II: HF = 201.7 g/l; no stirring (13)

	Base (0001)	Prism (11$\bar{2}$0)	Prism (10$\bar{1}$0)	Rhombohedron (10$\bar{1}$1)
(I) V =	7.2	1.15	1.17	0.97 mg/cm² day⁻¹
(II) V =	18.76	4.37	4.41	3.7 mg/cm² day⁻¹

Iceland Spar in HCl

Single exposed surface vertical. Stirring by gas evolved only. 15° (21). For surfaces cut, 1, parallel to principal axis; 2, parallel to cleavage plane; and 3, perpendicular to axis.

V_1: V_2: V_3 = 1.00: 1.05: 1.14

α-Chlorodinitrobenzene in Ether [1]

Prism (110) was compared with pinacoid (001). When the same value of C_s was used in the calculations for both faces the ratio $K_{(110)} : K_{(001)}$ varied with the concentration, reaching 0.4 in nearly saturated solution but approaching unity at slightly lower concentration. The author concludes that $K_{(110)} = K_{(001)}$ and that observed differences are due entirely to the fact that prism face is less soluble than the pinacoid. 15.1° and 19.8°; mechanical stirring.

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VELOCITY OF CRYSTALLIZATION

H. C. Burger

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FORMATION OF CRYSTAL NUCLEI

If extraneous influences are eliminated, the number, N, of nuclei which are formed at a given temperature should be proportional to the volume of the liquid and to the time. This number is a characteristic temperature function of the liquid. Transition in the crystal state from one form to another can occur spontaneously in a similar manner.

The measurements of the number of nuclei are however not very accurate, and the values given below represent, therefore, only order of magnitude. The first temperature given is the melting point. N is given in cm^{-3} sec^{-1}.

FORMATION DES NOYAUX CRISTALLINS

Si l'on élimine les influences extérieures, le nombre, N, de noyaux qui sont formés à une température donnée doit être proportionnel au volume du liquide et au temps. Ce nombre est pour un liquide une fonction caractéristique de la température. La transition à l'état cristallin d'une forme dans une autre peut se produire spontanément d'une manière analogue.

Les mesures du nombre de noyaux ne sont cependant pas très précises et les valeurs données ci-dessous ne représentent par conséquent que l'ordre de grandeur. La première température donnée est le point de fusion. N est exprimé en cm^{-3} sec^{-1}.

Diopside (Zermatt) (44)

t, °C	1310	1260	1200	1175
N	0	60	150	180

Melilite (Alnö, Sweden) (44)

t, °C	1180	1130	1100	1080	1060
N	0	120	300	430	500

Spinel (Amity, N. Y.) (44)

t, °C	1360	1225	1210	1200	1185	1175
N	0	60	180	270	420	570

Hedenbergite (Nordmarken) (44)

t, °C	1160	1120	1100	1080
N	0	70	180	250

BILDUNG VON KRISTALLKEIME

Wenn äussere Einflüsse eliminiert sind, sollte die Zahl, N, der bei gegebener Temperatur gebildeten Keime, dem Volum der Flüssigkeit und der Zeit proportional sein. Diese Zahl ist eine für die Flüssigkeit charakteristische Temperaturfunktion. In ähnlicher Weise können im kristallisierten Zustande spontan Übergänge von der einen Form in die andere stattfinden.

Die Messungen der Keimzahl sind aber nicht sehr genau, und die folgenden Werte geben deshalb nur die Grössenordnung an. N ist in cm^{-3} sec^{-1} gegeben.

FORMAZIONE DEI GERMI CRISTALLINI

Quando siano eliminate influenze esterne, il numero, N, di germi che si formano ad una data temperatura, deve essere proporzionale al volume di liquido ed al tempo. Questo numero è una funzione della temperatura caratteristica per il liquido. In maniera simile possono verificarsi trasformazioni (allo stato solido) di una forma cristallina nell'altra.

Le misure del numero di germi non sono però molto esatte, ed i valori seguenti danno perciò solo un'idea dell'ordine di grandezza. La prima temperatura data è il punto di fusione. N è dato in cm^{-3} sec^{-1}.

Aegirite (Lange Sundfjord) (44)

t, °C	1020	1000	975	950
N	0	80	130	160

3, 4-Dinitrobromobenzene, 3, 4-$(O_2N)_2C_6H_3Br$.—N is the number of nuclei of the stable form (M. P. = 59.5°) in the metastable crystal phase (M. P. = 34.8°) (45).

°C	10	±0	−10	−20	−30	−40	−50	−60	−70	−80
N	0.01	0.1	0.3	1	1	2	4	2	0.3	0.3

Betol (β-Napthyl Salicylate) $OHC_6H_4CO_2C_{10}H_7$.—N is a maximum at 15 ±5° and equals 0.7 to 2 (45).

Piperine, $C_{17}H_{19}NO_3$.—N is a maximum at 40 ± 5° and equals 0.2 to 10 (45); *cf.* (54).

CRYSTAL GROWTH

The linear crystallization velocity at the crystal-liquid boundary is a function of its temperature ([9, 10]) which, however, is seldom measured ([10, 53]), the temperature of the surrounding bath only, being known. The maximum linear crystallization velocity (K. G.) of the liquid or transition velocity (U. G.) of one crystal phase to another is a characteristic property of the substance, which, however, is very sensitive to impurities, so that the values recorded below may be 5–10% in error from this cause, in cases where another precision is not indicated.

Maximum linear crystallization (K. G.) and transition (U. G.) velocities. The unit is millicentimeters (10^{-3} cm) per sec; M. P. = melting point, °C; (*s*) = stable form; (*m*) = metastable form.

ACCROISSEMENT DU CRISTAL

La vitesse de cristallisation linéaire dans la zone cristal liquide est une fonction de sa température ([9, 10]) qui est cependant rarement mesurée ([10, 53]). Dans la plupart des cas on ne connait que la température du bain environnant. La vitesse maximum de cristallisation linéaire (K. G.) du liquide, ou la vitesse de transition (U. G.) d'une phase cristalline en une autre, est une propriété caractéristique de la substance qui est cependant très sensible aux impuretés. Les valeurs données ci-dessous peuvent donc être entachées d'une erreur de 5 à 10% lorsque la limite de l'erreur n'est pas exprimée.

Vitesse maximum de cristallisation linéaire (K. G.) et vitesse de transition (U. G.). L'unité est le millicentimètre (10^{-3} cm) par sec; M. P. = point de fusion, °C; (*s*) = forme stable; (*m*) = forme metastable.

Formula	Name	K. G. or U. G.	Lit.
H_3PO_4	Orthophosphoric acid, M. P. 36.6°	1.8±0.2	(5)
$Ca(NO_3)_2.4H_2O$	Calcium nitrate, 4-hydrate	22.7±0.3	(20, 22, 28)
$Cd(NO_3)_2.4H_2O$	Cadmium nitrate, 4-hydrate	50	(22)
$Na_2S_2O_3.5H_2O$	Sodium thiosulfate, 5-hydrate (*s*)	195	(37)
$Na_2S_2O_3.5H_2O$	Sodium thiosulfate, 5-hydrate (*m*)	185	(37)
$Na_2S_2O_3.5H_2O$	$m \rightarrow s$, U. G. =	83	(37)
$C_2H_3ClO_2$	Chloroacetic acid: $(M.P.)_I = 61.3°$; $(M.P.)_{II} = 56.2°$; $(M.P.)_{III} = 50.2°$		
	III → II, U. G. =	120	(37)
	II → I, U. G. =	95	(37)
	III → I, U. G. =	410	(37)
$C_3H_4Br_2O_2$	α, β-Dibromopropionic acid: *s*, M. P. = 64°, K. G. =	5.8	(37)
	m, K. G. =	7.2	(37)
	$m \rightarrow s$, U. G. =	1.4	(37)
$C_3H_8N_2O$	Ethylurea, M. P. = 95°	145	(37)
$C_4H_{10}O_4$	Erythritol (*s*)	45	(4, 37)
$C_6H_3ClN_2O_4$	3, 4-Dinitrochlorobenzene, M. P. 50°	6.5	(37)
$C_6H_3N_3O_7$	Picric acid	1430	(4)
$C_6H_4FNO_2$	*m*-Fluoronitrobenzene	25	(22)
$C_6H_4ClNO_2$	*m*-Chloronitrobenzene	1500	(22, 48)
$C_6H_4BrNO_2$	*m*-Bromonitrobenzene	1150	(3, 22)
$C_6H_4INO_2$	*m*-Iodonitrobenzene	200	(22)
$C_6H_6O_2$	Resorcinol I, M. P. = 110°, K. G. =	700	(27)
	Resorcinol II, M. P. = 108, K. G. =	450	(27)
	I → II, U. G. =	0.70±0.07	(27)
$C_6H_{11}NO_2$	Ethyl β-aminocrotonate (*s*)	58	(37)
C_7H_7NO	Formanilide	1.75	(13)
$C_7H_8O_2$	Guaiacol	9.3	(15)
$C_8H_6O_3$	Phthalide	25	(37)
$C_9H_{10}O_2$	Hydrocinnamic acid	470	(15)
$C_{10}H_9N$	α-Naphthylamine	110	(14)
$C_{10}H_{11}NO_4$	1-Hydroxy-2(*p*-nitrophenyl)-ethyl methyl ketone	2.5	(5)
$C_{12}H_{10}N_2$	Azobenzene, I, M. P. = 115°; II, M. P. = 128°		
	I → II, U. G. =	530	(37)

KRISTALLWACHSTUM

Die lineare Kristallisationsgeschwindigkeit an der Grenze Kristall-Flüssigkeit ist eine Funktion deren Temperatur ([9, 10]), welche aber selten gemessen ist ([10, 53]). Meistens ist nur die Temperatur des umgebenden Bades bekannt. Die maximale lineare Kristallisationsgeschwindigkeit der Flüssigkeit (K. G.) oder die Umwandlungsgeschwindigkeit (U. G.) der einen Kristallphase in die andere ist eine charakteristische Eigenschaft der Substanz, welche aber sehr empfindlich gegen Verunreinigungen ist. Deshalb können die unten angegebenen Werte mit einem Fehler von 5–10% behaftet sein, wenn keine andere Fehlergrenze genannt wird.

Maximale lineare Kristallisationsgeschwindigkeit (K. G.) und Umwandlungsgeschwindigkeit (U. G.). Die Einheit ist 10^{-3} cm pro sec; M. P. = Schmelzpunkt, °C; (*s*) = stabile Form; (*m*) = metastabile Form.

ACCRESCIMENTO DEI CRISTALLI

La velocità lineare di cristallizzazione in corrispondenza della zona di contatto cristallo-liquido è una funzione della temperatura ([9, 10]) alla quale essa si trova; questa temperatura però raramente è stata misurata direttamente ([10, 53]). Per lo più si conosce soltanto la temperatura del bagno nel quale il sistema in esame è immerso. La velocità lineare massima di cristallizzazione di un liquido (K. G.) o di trasformazione (U. G.) di una fase cristallina nell'altra è una proprietà caratteristica delle sostanze. Essa risente però molto l'influenza delle impurezze, per modo che i valori sotto riportati possono essere inesatti del 5–10%, quando non siano indicati altri limiti di errore.

Velocità lineare massima di cristallizzazione (K. G.) e velocità di trasformazione (U. G.). L'unità è 10^{-3} cm al secondo; M. P. = punto di fusione, °C; (*s*) = forma stabile, (*m*) = forma metastabile.

Formula	Name	K. G. or U. G.	Lit.
$C_{12}H_{11}N$	Diphenylamine	190	(14, 15)
$C_{12}H_{14}O_4$	Apiol I, M. P. = 30°	12	(46)
	II, M. P. = 27.5°	24	(46)
$C_{13}H_{10}O$	Benzophenone	97±2.5	(14)
$C_{13}H_{10}O_3$*	Salol I, M. P. = 42°	6.5±0.2	(10, 15)
	II, M. P. = 38.8°	1.8	(15)
	III, M. P. = 28.3°	0.45	(15)
$C_{13}H_{11}N$	Benzalaniline	26	(22)
$C_{13}H_{13}N$	Benzylaniline	2.1	(22)
$C_{14}H_{10}O_2$	Benzil	715	(4)
$C_{14}H_{10}O_3$	Benzoic anhydride	53	(15)
$C_{17}H_{12}O_3$	Betol (β-Napthyl salicylate) I, M. P. = 95°	1.7	(46)
	III, M. P. = 93°	0.8	(46)
$C_{18}H_{18}N_2O_4$	Saliperin (Antipyrine salicylate) I, M. P. = 91.8°	3.0	(5)
	II, M. P. = 86.3°	5.0	(5)
$C_{17}H_{19}NO_3$*	Piperine		
$C_{19}H_{16}$	Triphenylmethane	33±3	(37)
$C_{19}H_{17}N_3$	Triphenylguanidine, I, M. P. = 139°	21	(27)
	II, M. P. = 144.2°	6.4	(27)
	I → II, U. G. =	1.5	(27)
$C_{57}H_{110}O_6$	Tristearin, M. P. = 71°	2.8	(27)

* For effect of electric and magnetic fields on undercooled compound, *v.* ([54]).

LITERATURE

(For a key to the periodicals see end of volume)

([1]) Bekier, *93*, **78**: 178; 12. ([2]) Berger, *93*, **85**: 75; 14. ([3]) Block, *7*, **78**: 385; 12. ([4]) Bogojawlensky, *7*, **27**: 585; 98. ([5]) Borodowsky, *7*, **43**: 75; 03. ([6]) Boussu, *34*, **176**: 93; 23. ([7]) Boussu, *34*, **177**: 119; 23. ([8]) Burger, *Diss.*, Utrecht, 1918. ([9]) Burger, *64P*, **23**: 616; 20. ([10]) Burger, *64P*, **23**: 691; 20. ([11]) Dean and Hudson, *1*, **26**: 1778; 24. ([12]) Doelter, *189*, **1903**: 608. ([13]) Dreyer, *7*, **48**: 467; 04. ([14]) Freundlich, *7*, **75**: 245; 11. ([15]) Friedländer and Tammann, *7*, **24**: 152; 97. ([16]) Gernez, *34*, **95**: 1278; 82. ([17]) Gernez, *34*, **97**: 1298; 83. ([18]) Gernez, *34*, **97**: 1366; 83. ([19]) Gernez, *34*, **97**: 1433; 83.

(20) Grinakowski, *53*, **47**: 780; 15. (21) Hartmann, *93*, **88**: 128; 14. (22) Hasselblatt, *7*, **83**: 1; 13. (23) Isaac, *5*, **84**: 344; 11. (24) Jablczynski, *7*, **82**: 115; 13. (25) Kittl, *93*, **77**: 335; 12. (26) Kittl, *93*, **80**: 79; 13. (27) Lautz, *7*, **84**: 611; 13. (27.5) Le Blanc and Schmandt, *7*, **77**: 614, 11. (28) Leenhardt, *Recherches sur la vitesse de la cristallisation des sels hydratés*, Paris, 1908. (29) Lidbury, *7*, **39**: 453; 01.
(30) Marc, *7*, **61**: 385; 08. (31) Marc, *7*, **67**: 470; 09. (32) Marc, *7*, **73**: 685; 10. (33) Marc, *7*, **75**: 710; 11. (34) Marc, *7*, **79**: 71; 12. (35) Marc and Wenk, *7*, **68**: 104; 09. (36) Moore, *7*, **12**: 545; 93. (37) Müller, *7*, **86**: 177; 14. (38) Olivari, *22*, **22 II**: 697; 13. (39) Ostwald, *7*, **22**: 289; 97.
(40) von Pickardt, *7*, **42**: 17; 02. (41) Schaum and Rörig, *93*, **132**: 77; 23. (42) Schaum and Unger, *93*, **132**: 90; 23. (43) Schmidt, *7*, **75**: 305; 11. (44) Shumov-Deleano and Dittler, *189*, **1911**: 753. (45) Tammann, *7*, **25**: 441; 98. (46) Tammann, *7*, **29**: 51; 99. (47) Tammann, *7*, **72**: 609; 10. (48) Tammann, *in* van Bemmelen, *Gedenkboek*, p. 297. Helder, Boer, 1910. (49) Tumlirz, *75*, **104**: 245; 95.
(50) Walton and Braun, *1*, **38**: 317; 16. (51) Walton and Judd, *50*, **18**: 722: 14. (52) Wigand, *7*, **75**: 235; 11. (53) Wilson, *3*, **50**: 238; 00. (54) Kondoguri, *53* (*Phys. Pt.*), **58**: 279; 26.

INTERDIFFUSION OF GASES AND VAPORS

W. P. Boynton and W. H. Brattain

By the coefficient of diffusion of one gas or vapor into another is meant the quantity D occurring in the equation $\frac{\delta p_1}{\delta t} = \frac{\delta}{\delta x}\left(D\frac{\delta p_1}{\delta x}\right)$; t = time, p_1 = partial pressure of the diffusing gas, and x = a length in the direction of the diffusion (**14, 15, 22, 24**). As D varies only slightly with p_1, a good first approximation is $\frac{\delta p_1}{\delta t} = D\frac{\delta^2 p_1}{\delta x^2}$. For a given pair of gases (A, B), the value of D for diffusion of A into B is the same as that for B into A; also $D = D_0\left(\frac{T}{T_0}\right)^m \frac{p_0}{p}$, where D_0 = the value of D at T_0 (=273°K) and p_0 (= 1 atm.), D is its value at absolute temperature T and pressure p, and m is a constant which theoretically lies between 1.5 and 2.0, and practically may be taken either as 1.75 or as 2.00, depending upon the gases (**9, 10, 14, 15**). For methods of measurement, *see* (**13, 17, 22**). A temperature gradient in a mixture of two gases produces a diffusion of the more massive molecules towards the region of lower temperature (**1, 2, 3, 4, 5**). For separation of gases by diffusion through porous septa, *see* (**7, 20**); for diffusion through metals, *see* p. 77; through glass, rubber, and other solids, *see* p. 76. For diffusion of radioactive gases, *see* Vol. I, p. 364; of ions in gases, consult the index at the end of the last volume.

A-B-TABLE

Diffusion of Gases into Gases

$D = D_0\left(\frac{T}{T_0}\right)^m \frac{p_0}{p}$, m = 2.00 for all cases except those marked * for which m = 1.75

Gases	D_0, cm/sec	Lit.	Gases	D_0, cm/sec	Lit.
He-Ar	0.641*	(12, 19)	H_2-CO_2	0550*	(6, 13, 17, 19)
H_2-O_2	.697*	(6, 11, 13, 17)	H_2-CH_4	.625*	(17)
O_2-N_2	.181*	(11, 17)	H_2-C_2H_4	.486*	(17)
O_2-CO	.185*	(13, 17)	H_2-C_2H_6	.459*	(17)
O_2-CO_2	.139	(13, 17)	H_2-air	.611*	(17, 21)
O_2-air	.178*	(17)	N_2O-CO_2	.096	(13, 17)
H_2-SO_2	.480*	(13)	CO-CO_2	.137*	(13, 17)
H_2-N_2	.674*	(11)	CO-C_2H_4	.116*	(17)
H_2-N_2O	.535*	(17)	CO_2-CH_4	.153*	(13, 17)
H_2-CO	.651*	(13, 17)	CO_2-air	.138	(13, 17, 23)

Diffusion of Vapors into Gases

Vapor	Values of D_0 (cm²/sec), and of m			
	Air	CO_2	H_2	Lit.
Hg, mercury	0.1124†			(16)
I_2, iodine	0.0654†			(16)
	0.097			(13.1)
H_2O, water	0.220*	0.1387	0.7516*	(9, 10, 11.1, 25)

C-TABLE.—The C-Arrangement (*v.* Vol. III, p. viii)

Vapor	Values of D_0 (cm²/sec), and of m			
	Air	CO_2	H_2	Lit.
CS_2, carbon disulfide	0.0892	0.063	0.3689	(22, 25)
CH_2O_2, formic acid	0.1308	0.0874	0.5104	(25)
CH_4O, methyl alcohol	0.1325	0.0879	0.5059*	(25)
$C_2H_4O_2$, acetic acid	0.1064	0.0716	0.4163	(18, 25)
$C_2H_4O_2$, methyl formate	0.0872*			(8)
C_2H_6O, ethyl alcohol	0.102	0.0685	0.3753	(11.1, 25)
$C_3H_6O_2$, propionic acid	0.0829	0.0588	0.3297	(18, 25)
$C_3H_6O_2$, ethyl formate	0.0840*	0.0573*	0.3368*	(18, 25)
$C_3H_6O_2$, methyl acetate	0.084	0.0567	0.3330	(8, 18, 25)
C_3H_7Br, isopropyl bromide	0.0902			(18)
C_3H_7Br, *n*-propyl bromide	0.085			(18)
C_3H_7I, isopropyl iodide	0.0802			(18)
C_3H_7I, *n*-propyl iodide	0.079			(18)
C_3H_8O, isopropyl alcohol	0.0818			(18)
C_3H_8O, *n*-propyl alcohol	0.085	0.0577	0.3153	(18, 25)
$C_4H_8O_2$, butyric acid	0.067	0.0476	0.264	(18, 25)
$C_4H_8O_2$, isobutyric acid	0.0679	0.0471	0.2713	(18, 25)
$C_4H_8O_2$, methyl propionate	0.0735	0.0528	0.2949	(8, 18, 25)
$C_4H_8O_2$, propyl formate	0.0712	0.0490	0.2810	(18, 25)
$C_4H_8O_2$, ethyl acetate	0.0715	0.0487	0.273	(18, 25)
$C_4H_{10}O$, *n*-butyl alcohol	0.0703	0.0476	0.2716	(18, 25)
$C_4H_{10}O$, isobutyl alcohol	0.0727	0.0483	0.2771	(18, 25)
$C_4H_{10}O$, trimethyl carbinol	0.087			(18)
$C_4H_{10}O$, ether	0.0778	0.05525	0.2964	(8, 18, 22, 25)
$C_4H_{11}N$, butylamine	0.0821			(18)
$C_4H_{11}N$, diethylamine	0.0884			(18)
$C_4H_{11}N$, isobutylamine	0.0853			(18)
$C_5H_{10}O_2$, isovaleric acid	0.0544	0.0376	0.2123	(18, 25)
$C_5H_{10}O_2$, *n*-valeric acid	0.050			(18)
$C_5H_{10}O_2$, ethyl propionate	0.0653	0.0450	0.2365	(18, 25)
$C_5H_{10}O_2$, isobutyl formate	0.0705			(18)
$C_5H_{10}O_2$, methyl butyrate	0.0633	0.0446	0.242	(18, 25)
$C_5H_{10}O_2$, methyl isobutyrate	0.0639	0.0451	0.2569	(18, 25)
$C_5H_{10}O_2$, propyl acetate	0.067			(11.1, 18)
$C_5H_{12}O$, *n*-amyl alcohol	0.0589	0.0422	0.2349	(25)
$C_5H_{12}O$, amyl alcohol, fermentation	0.0585	0.0419	0.234	(25)
C_6H_6, benzene‡	0.077	0.0528	0.2948*	(11.1, 25)
C_6H_7N, aniline	0.6095			(13.1)
$C_6H_{12}O_2$, caproic acid	0.050*			(18)
$C_6H_{12}O_2$, isocaproic acid	0.0513*			(18)
$C_6H_{12}O_2$, amyl formate	0.0543*			(18)
$C_6H_{12}O_2$, *n*-butyl acetate	0.058§			(18)
$C_6H_{12}O_2$, ethyl *n*-butyrate	0.0579	0.0407	0.2236	(18, 25)
$C_6H_{12}O_2$, ethyl isobutyrate	0.0591	0.0413	0.2289	(18, 25)
$C_6H_{12}O_2$, isoamyl formate	0.058§			(18)
$C_6H_{12}O_2$, isobutyl acetate	0.0612*	0.0425*	0.2364*	(18, 25)
$C_6H_{12}O_2$, methyl valerate	0.0569*			(18)
$C_6H_{12}O_2$, propyl propionate	0.057	0.0395	0.2115	(18, 25)
$C_6H_{14}O$, hexyl alcohol	0.0499	0.0351	0.1997	(25)
C_7H_7Cl, benzyl chloride	0.066			(11.1, 18)
C_7H_7Cl, *m*-chlorotoluene	0.054*			(18)
C_7H_7Cl, *o*-chlorotoluene	0.059			(18)
C_7H_7Cl, *p*-chlorotoluene	0.051			(18)
C_7H_8, toluene	0.0709			(13.1)
$C_7H_{14}O_2$, ethyl valerate	0.0512	0.0367	0.2052	(18, 25)
$C_7H_{14}O_2$, isobutyl propionate	0.0529*	0.0366*	0.2029*	(18, 25)
$C_7H_{14}O_2$, isopropyl isobutyrate	0.059§			(18)
$C_7H_{14}O_2$, propyl butyrate	0.0530	0.0364	0.2059	(18, 25)
$C_7H_{14}O_2$, propyl isobutyrate	0.0549	0.0388	0.212	(18, 25)
C_8H_{10}, ethylbenzene	0.0658*			(18)
C_8H_{10}, *m*-xylene	0.059*			(18)
C_8H_{10}, *o*-xylene	0.062*			(18)
C_8H_{10}, *p*-xylene	0.056			(18)

C-TABLE.—(*Continued*)

Vapor	Values of D_0 (cm²/sec), and of m			
	Air	CO_2	H_2	Lit.
$C_8H_{16}O_2$, amyl propionate	0.046	0.0347*	0.1914*	(18, 25)
$C_8H_{16}O_2$, isobutyl butyrate	0.0468	0.0327	0.1850	(18, 25)
$C_8H_{16}O_2$, isobutyl isobutyrate	0.0457	0.0364*	0.191	(18, 25)
$C_8H_{16}O_2$, propyl valerate	0.0466	0.0341	0.1893	(18, 25)
C_8H_{18}, *n*-octane	0.0505			(13.1)
C_9H_{12}, isopropylbenzene	0.0489			(18)
C_9H_{12}, mesitylene	0.056			(18)
C_9H_{12}, *n*-propylbenzene	0.0481			(18)
$C_9H_{18}O_2$, amyl butyrate	0.040			(18)
$C_9H_{18}O_2$, amyl isobutyrate	0.0419	0.9307	0.171	(18, 25)
$C_9H_{18}O_2$, isobutyl valerate	0.0424	0.0308	0.1730	(18, 25)
$C_{10}H_8$, naphthalene	0.0513			(13.1)
$C_{10}H_{10}O_2$, isosafrol	0.0455*			(18)
$C_{10}H_{10}O_2$, safrol	0.0434*			(18)
$C_{10}H_{12}O_2$, eugenol	0.0377			(18)
$C_{12}H_{10}$, diphenyl	0.0610			(13.1)
$C_{12}H_{12}N_2$, benzidine	0.0298			(13.1)
$C_{14}H_{10}$, anthracene	0.0421			(13.1)

* m = 1.75. † Into N_2. ‡ Into O_2, D_0 = 0.0633, m = 1.75 (19).
§ Value of m is not known.

LITERATURE

(For a key to the periodicals see end of volume)

(1) Chapman, *3*, **34**: 146; 17. (2) Chapman, *5*, **93**: 1; 17. (3) Chapman, *5*, **99**: 385; 21. (4) Chapman and Dootson, *3*, **33**: 248; 17. (5) Chapman and Hainsworth, *3*, **48**: 593; 24. (6) Deutsch, *Diss.*, Halle, 1907. (7) Fischer, Schrader and Jager, *416*, **4**: 289; 23. (8) Griboedov, *53*, (*Phys. sect.*), **25**: 36; 93. (9) Guglielmo, *23*, **17**: 54; 81. **18**: 93; 82.
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(20) Schmidt and Lucke, *96*, **8**: 152; 22. (21) Schulze, *7*, **89**: 168; 15. (22) Stefan, *75*, **63**: 63; 71. **65**: 323: 72. **68**: 385; 73. **98**: 1418; 89. *8*, **41**: 723; 90. (23) Waitz, *8*, **17**: 201; 82. (24) Waitz, in Winkelmann, *Handbuch der Physik*, I, pt. 2: 1415; 08. (25) Winkelmann, *8*, **22**: 1, 152; 84. **23**: 203; 84. **26**: 105; 85. **33**: 445; 88. **36**: 93; 89.

COEFFICIENTS OF DIFFUSION IN LIQUIDS

H. R. Bruins

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Abbreviations and Conventions

Δ.—Defined by the equation $\frac{\partial c}{\partial t} = \Delta \frac{\partial^2 c}{\partial x^2}$ where c is the concentration of the diffusing substance at the time t and x is the distance in the direction of the diffusion. The diffusion coefficient, Δ, (*"true"* diffusion coefficient), is thus a function of c. In the following tables these *"true"* diffusion coefficients are in all cases marked with an *asterisk* and they correspond to the concentration given in the c-column of the table, this concentration being also marked with an asterisk.

All unmarked values in the Δ-column of the tables represent some kind of "mean" value of Δ over a range of concentration: they correspond to a diffusion *from* an initial concentration, c_0, (appearing in the c-column) *into* the pure solvent (unless otherwise indicated). These *"mean"* values depend also on the method employed and in some cases on the type of apparatus used; values obtained by different methods are therefore *not comparable.*

As far as possible the experimental methods employed in determining these *"mean"* values are indicated by Roman numerals as follows:

I. Method of steady state.
II. Second method of Graham (27, 93).
III. Method of Stefan-Schuhmeister (118).
IV. First method of Graham (114, 143).
V. Indicator method (2, 127).

$c = 0^*$ indicates diffusion in very dilute solution. Δ is then practically identical with Δ_∞ (diffusion coefficient for infinite dilution). Temperature coefficient $\alpha = \frac{\Delta_{t_1} - \Delta_{t_2}}{\Delta_{t_1}(t_1 - t_2)}$, where $t_1 > t_2$.

Units

Values of Δ are in cm²/sec. Values of c are in gram-moles per liter except in the case of electrolytes where they are in g-equiv. per liter.

Accuracy

The values following the ± sign indicate (*a*) in the case of the "true" Δ, the estimated *possible* error in the *absolute* value; resp. (*b*) in the case of the "mean" Δ, the *possible* deviation from the correct value for the experimental method employed. The actual errors will *probably* not exceed these values. The reliability of the Δ values is indicated in many cases as follows:

Symbol	A	B	C	D	E	F
Error probably < ±	2%	3%	5%	7%	10%	(?)

DIFFUSION IN WATER† (OR IN A GIVEN AQUEOUS SOLUTION)

1. Elementary Substances—Δ-Table

Cl_2‡

t, °C	c_0 (resp. c^*)	$10^5\Delta$	Method	Lit.
12	0.1	1.4	II	(42)
16	0.12§	1.26‖		(74)
Br_2				
12	0.1	0.9	II	(42)
H_2; *cf.* (6, 43, 66)				
10	0*	4.3*F		(75)
16	0*	4.7*F		(74)
21	0*	5.2*F		(74)
I_2;¶ *cf.* (17, 42)				

t, °C	c_0	$10^5\Delta$	C, KI	Method	Lit.
20	0.046	1.15A	1*N*	II	(90)
		1.25A	2*N*		
		1.31A	3*N*		
		1.35A	4*N*		

† For most of the radioactive substances, *v.* Vol. I, p. 364.
‡ Hydrolyzed! § Saturated at 1 atm. ‖ Probably too low.
¶ In KI. For Δ in solutions of NH_4Br, NH_4I, NaBr, NaI and KBr. *v.* (90).

I_2.—(*Continued*)

t, °C	c_0	$10^5\Delta$	C, KI	Method	Lit.
25	0.05	1.25B	0.25N		(40)
		1.25B	0.5N		
		1.38B	1.0N		
		1.46B	2.0N		
		1.48B	3.0N		
		1.48B	4.5N		

N_2; *cf.* (43)

t, °C	c_0 (resp. c*)	$10^5\Delta$	C, NaCl, %		Lit.
19	0*	1.95*E	20		(3)
	0*	1.8*E	30		
	0*	1.8*E	40		
22	0*	2.02*E	0		(74)

O_2; *cf.* (43, 66, 74)

18.0	0*	1.98*±0.04	1		(18, 19)
18	0*	1.7*E	20		(3)
	0*	1.6*E	30		(3)
	0*	1.1*?	40		(3)

Rn; *cf.* (141)

18	0*	1.14*±0.07			(112)

2. Chemical Compounds—𝔅-Table

Standard Arrangement (*v.* Vol. III, p. viii)

HCl;† *cf.* (4, 34, 35, 36, 52, 59, 68, 114, 122, 140)

t, °C	c_0 (resp. c*)	$10^5\Delta$	Method	Lit.
0	9	2.7	II, IV	(115, 116)
	7	2.4		
	4	2.1		
	3	2.0		
	2	1.8		
	0.4	1.6		
5	6	2.4	II, IV	(115, 116)
	1.3	1.9		
	0.4	1.8		
10	9	3.3	II, IV	(115, 116)
	6.5	3.0		
	2.5	2.5		
	0.8	2.2		
	0.5	2.1		
13	4.5	3.0	II, IV	(115, 116)
	0.8	2.6(?)		
15	2.5	2.9	II, IV	(115, 116)
12.0†	1.0	2.27 ± 0.02	II	(93)
	0.5	2.24 ± 0.02		
	0.25	2.26 ± 0.02		
	0.1	2.29 ± 0.03		
	0.05	2.31 ± 0.03		
	0.02	2.34 ± 0.04		
	0.01	2.38 ± 0.04		
16.0†	0.5	2.44 ± 0.03	II	(93)
	0.1	2.47 ± 0.03		
13	0.175*	2.3*E		(134)
	2.0*	3.8*E		
19	3.2*	4.5*E		(134)
	1.0*	3.0*E		
	0.3*	2.7*E		
	0.2*	2.7*E		
	0.1*	2.5*E		

H_2S (in 20% gelatin); *cf.* (43)

15	0*	1.4*F		(66)

† α = 0.019, between 12 and 16°C (93).

H_2SO_4; *cf.* (34, 35, 36, 52, 59, 140)

t, °C	c_0 (resp. c*)	$10^5\Delta$	Method	Lit.
8	1.0	1.24D	II	(115)
	0.55	1.17D		
	0.24	1.17D		
	0.16	1.13D		
	0.03	1.25D		
13	8.6	1.50D	II	(115)
	0.6	1.44D		
	0.3	1.34D		
10	1.0	1.21 ± 0.06	II	(4)
	2.0	1.26 ± 0.06		
18	10■	2.7*E		(134)
	5*	2.2*E		
	3*	1.9*E		
	1*	1.6*E		
	0.4*	1.5*E		
	0.05■	1.5*†		
20.0	2.0	1.50B	II	(103)
	1.5	1.56B		
	1.0	1.58B		
	0.75	1.60B		
	0.5	1.62B		
	0.25	1.63B		
	0.1	1.73B		

N_2O; *cf.* (66)

16	0*	1.54*E		(75)

NH_3; *cf.* (43, 66, 92, 140)

5	3.5	1.24C	II	(115)
	0.7	1.24C		
8	1.0	1.36C	II	(4)
12	1.0	1.64B	II	(4)
15	1.0	1.77C	II	(1)
8	‡	1.08E	I	(75)
10	‡	1.14E	I	(75)
15	‡	1.26E	I	(75)

HNO_3; *cf.* (35, 52, 59, 140)

6	3.0	1.78C	II	(115)
	1.0	1.82C		
	0.84	1.75C		
9	2.0	2.04C	II	(115)
	1.5	2.06C		
	0.8	2.01C		
	0.6	1.94C		
	0.1	2.00C		
12	0.55	2.21B	II	(4)
20.0	2.0	2.49B	II	(103)
	1.5	2.47B		
	1.0	2.50B		
	0.5	2.58A		
	0.25	2.59A		
	0.1	2.60A		
	0.05	2.62A		
20	4.0*	2.9*E		(134)
	1.0*	2.7*E		
	0.4*	2.6*E		
	0.1*	2.4*E		

NH_4NO_3; *cf.* (52)

15	0.4	1.3F	II	(59)

† Probably too low. ‡ Satd. at 1 atm.

NH_4Cl; *cf.* (52, 59, 84, 115, 140)

t, °C	c_0 (resp. c^*)	$10^5\Delta$	Method	Lit.
0†	1.0	0.93A	V	(126)
20†	1.0	1.64A	V	(126)
30†	1.0	2.07A	V	(126)
40†	1.0	2.50A	V	(126)
8	4.5	1.3E	III	(118)
12	2.3	1.5E	III	(118)
	5.0	1.7E		
18	0.2	1.5C	IV	(114)

NH_4HSO_4 (59)

Diffuses as a mixture of $(NH_4)_2SO_4$ and H_2SO_4

$(NH_4)_2SO_4$; *cf.* (46, 47, 58)

0†	1.0	0.47B	V	(125)
20†	1.0	0.92B	V	(125)
15	0.5	0.73F	II	(59)

H_3PO_4; *cf.* (52)

20.0	3.0	0.75 ± 0.03	II	(103)
	2.0	0.76 ± 0.03		
	1.5	0.79 ± 0.03		
	1.0	0.80 ± 0.03		
	0.5	0.85 ± 0.03		
	0.25	0.89 ± 0.03		

CO_2; *cf.* (43, 66, 147, 148, 149, 150)

10	0*	1.46*B		(74, 75, 120)
15	0*	1.60*B		(74, 75, 120)
20	0*	1.77*B		(74, 75, 120)
18.0	0*	1.71* ± 0.03		(18, 19)

For other C-compounds, *v.* p. 69.

$Pb(NO_3)_2$

12	0.8	0.76C	II	(115)
	0.2	0.82C		

$ZnCl_2$

15	0.1	0.73F	II	(59)

$ZnSO_4$; *cf.* (46, 47, 59, 84, 118)

0	4*	0.14*F		(119, 142)
15	1*	0.27*F		(119, 142)
18	4*	0.24*F		(119, 142)
8	2.75*	0.20*		
	1.25*	0.23*		
	0.75*	0.26*		
	0.375*	0.31*		
	0.125*	0.33*	E to F	(134)
	0.025*	0.42*		
	0.005*	0.44*		
20	3.0*	0.38*		
	0.55*	0.42*		
	0.05*	0.54*		

$Zn(NO_3)_2$; *cf.* (59)

20	4.0*	0.89*E		(134)
	0.7*	0.92*E		
	0.1*	1.02*E		

$Zn(CHO_2)_2$, Formate

19.0	0.5*	0.54*(?)		(119)

$Zn(C_2H_3O_2)_2$, Acetate

0	2.0*	0.14*(?)		(119)
18	2.0*	0.24*(?)		

† In 0.5 % agar.

$CdSO_4$

t, °C	c_0 (resp. c^*)	$10^5\Delta$	Method	Lit.
19.0	2.0*	0.28*(?)		(119)

$HgCl_2$

10	0.25	0.68	II	(130)
13	0.25	0.76	II	(130)
18	0.25	0.92	II	(130)

$CuCl_2$

6	2.0	0.50E	III	(118)

$CuSO_4$; *cf.* (60, 107, 125)

5	1.6	0.24F	III	(118)
	2.2	0.25F		
8	1.1	0.27F	III	(118)
	2.2	0.25F		
14	2.5	0.31 ± 0.02	IV	(143)
	1.2	0.35 ± 0.02		
	0.4	0.39 ± 0.02	IV	(143)
10	2.0*	0.20*		
	1.0*	0.26*		
	0.3*	0.31*		
	0.1*	0.40*		
17	2.0*	0.26*		
	1.0*	0.29*	E to F	(134)
	0.5*	0.34*		
	0.3*	0.38*		
	0.1*	0.45*		
20	0.5*	0.38*		
	0.1*	0.50*		
	0.01*	0.58*		

$AgNO_3$

3	0.14	0.94C	II, IV	(115, 116)
7	5	0.7C	II, IV	(115, 116)
	2	0.88C		
	0.3	1.04C		
9	0.02*	1.1*E		(134)
12	3.9*	0.6*E		(134)
	0.9*	1.0*E		
	0.1*	1.15*E		
12.0	0.1	1.22 ± 0.04	II	(77)
14.0	0.05	1.33 ± 0.04	II	(77)
15.0	0.17	1.28 ± 0.04	II	(77)

$MnCl_2$

15	0.5	0.72F	II	(59)

$MnSO_4$

15	0.5	0.35F	II	(59)

$Mn(NO_3)_2$

15	0.3	0.7F	II	(59)

$FeCl_2$; *cf.* (59)

15	0.2	0.73	II	(14)
	0.2	0.69†		
	0.2	0.61‡		

$FeSO_4$

15	0.5	0.39F	II	(59)

$Fe(NO_3)_3$

15	0.3	0.57	II	(14)

† In 0.1*N* HCl. ‡ In 20 % HCl.

$CoCl_2$;† *cf.* (113, 118)

t, °C	c_0 (resp. c^*)	$10^5\Delta$	Method	Lit.
0	0.1	0.5		(140)
20	0.1	1.0		(140)
40	0.1	1.5		(140)

$NiCl_2$‡

0	0.16	0.5		(140)
20	0.16	1.0		(140)
40	0.16	1.7		(140)

$Ni(NO_3)_2$ (113)

$UO_2(NO_3)_2$

18	0.4	0.67	II	(71)
	0.4	0.51§		

H_3BO_3

20.0	1.5	0.94 ± 0.03	II	(103)
	1.0	0.94 ± 0.03		
	0.75	0.95 ± 0.03		
	0.5	0.96 ± 0.03		
	0.1	1.01¶		
	0.05	1.10¶		

$MgCl_2$;‖ *cf.* (36, 59, 140)

0	1.0	0.61A	V	(126)
20	1.0	1.12A	V	(126)
30	1.0	1.42A	V	(126)
40	1.0	1.73A	V	(126)

$MgSO_4$; *cf.* (46, 47, 59, 118, 122)

0‖	1.0	0.27B	V	(125)
20‖	1.0	0.51B	V	(125)
7	2.2	0.35D	II	(115)
	1.0	0.35D		
	0.5	0.38D		
10	3.2	0.31D	II	(115)
	0.4	0.39D		

$Mg(NO_3)_2$

15	0.5	0.8F	II	(59)

$Ca(OH)_2$†

0	0.2	0.9		(140)
20	0.2	1.6		(140)
40	0.2	2.5		(140)

$CaCl_2$; *cf.* (118, 140)

9	5	0.82D	II	(115)
	0.4	0.74D		
	0.3	0.80D		
0‖	1.0	0.65A	V	(126)
20‖	1.0	1.16A	V	(126)
30‖	1.0	1.48A	V	(126)
40‖	1.0	1.83A	V	(126)

$Ca(NO_3)_2$

14	0.30	0.81 ± 0.03	II	(77)
	0.14	0.85 ± 0.03		

† In 2 % agar, probably *ca.* 10 % lower than in water.
‡ In 2 % agar, probably *ca.* 10 % + lower than in water.
§ In 8*N* HNO_3.
¶ Probably too high.
‖ In 0.5 % agar.

$Sr(OH)_2$†

t, °C	c_0 (resp. c^*)	$10^5\Delta$	Method	Lit.
0	0.1	0.8		(140)
20	0.1	1.5		(140)
40	0.1	2.3		(140)

$Ba(OH)_2$†

0	0.08	0.9		(140)
20	0.08	1.5		(140)
40	0.08	2.4		(140)

$BaCl_2$; *cf.* (86, 140)

0‡	1.0	0.66A	V	(126)
	0.1	0.68A		
20‡	1.0	1.16A	V	(126)
	0.1	1.22A		
30‡	1.0	1.48A		
40‡	1.0	1.80A		
8	2.0	0.76D	II	(115)
	0.3	0.75D		

$RaCl_2$§

18	0*	0.77*		(70)

LiOH;† *cf.* (59)

0	0.3	0.7		(140)
20	0.3	1.3		(140)
40	0.3	2.1		(140)

LiCl;‖ *cf.* (34, 36, 59, 118, 126)

For Δ in solutions of various organic substances, *see* (100).

9.0	4.2	0.84	±0.01 − 0.02	II	(77, 81, 93)
	2.0	0.81			
	1.0	0.81			
	0.5	0.80			
	0.25	0.81			
	0.1	0.83			
	0.05	0.85			
11.0	0.02	0.91 ± 0.03		II	(77, 81, 93)
	0.01	0.93 ± 0.03			
13.0	0.55	0.92 ± 0.03			
15.0	0.28	0.97 ± 0.03			
18.0	0.5	1.06 ± 0.02			
	0.05	1.12 ± 0.02			
20.0¶	1.0	1.12B			(86)
30.0¶	1.0	1.32B			(86)

LiBr

8	4.3	1.0E	III	(118)
	2.3	0.9E		

LiI

10	1.2	0.92E	III	(118)
13	0.9	0.90E		

Li_2SO_4

15	0.6	0.53F	II	(59)

$LiNO_3$

15	0.5*	1.0*F	II	(59)

NaOH;** *cf.* (4, 34, 35, 59, 115, 134, 140)

9	0.02*	1.2*F		(134)
12	4.0*	1.1*E		(134)
	1.0*	1.2*E		
	0.1*	1.3*E		

† In 2 % agar, probably *ca.* 10 % less than in water.
‡ In 0.5 % agar.
§ In 0.01*N* HCl.
‖ α = 0.027 between 9 and 18°C; *cf.* (93). ¶ In 2 % agar.
** α = 0.023 between 8 and 15°; *cf.* (93).

NaOH.—*(Continued)*

t, °C	c_0 (resp. c^*)	$10^5\Delta$	Method	Lit.
12	0.5	1.33C	II	(4)
13	2.0	1.23C	II	(4)
	0.54	1.37C		
8.0	0.5	1.19 ± 0.01	II	(93)
	0.1	1.22 ± 0.01		
15.0	2.0	1.36 ± 0.02	II	(93)
	1.0	1.39 ± 0.02		
	0.5	1.41 ± 0.02		
	0.2	1.45 ± 0.02		
	0.1	1.47 ± 0.02		
	0.05	1.49 ± 0.04		
	0.02	1.51 ± 0.04		
	0.01	1.54 ± 0.04		

NaCl;† *cf.* (4, 13, 15, 36, 44, 59, 67, 68, 111, 115, 116, 122, 126, 127, 129, 134, 137, 140, 147)

18.0	0.05*	1.26* ± 0.02		(24, 25, 26)
	0.1*	1.24* ± 0.02		
	0.2*	1.21* ± 0.02		
	0.4*	1.20* ± 0.02		
	0.6*	1.21* ± 0.02		
	0.8*	1.22* ± 0.02		
	1.0*	1.24* ± 0.02		
	1.5*	1.27* ± 0.02		
	2.0*	1.30* ± 0.02		
	2.5*	1.33* ± 0.02		
	3.0*	1.36* ± 0.02		
	3.5*	1.39* ± 0.02		
	4.0*	1.43* ± 0.02		
	4.5*	1.46* ± 0.02		
	5.0*	1.50* ± 0.02		
	5.4*	1.54* ± 0.02		
5.0	5.4	0.83	II	(93)
	2.75	0.83		
	0.9	0.84 ±0.01 to 0.02		
	0.5	0.84		
	0.23	0.86		
	0.1	0.87		
	0.05	0.89 ± 0.03		
	0.02	0.90 ± 0.03		
	0.01	0.91 ± 0.03		
18.0	0.9	1.23 ± 0.02	II	(93)
	0.1	1.30 ± 0.02		
5.0‡	0.05	0.89	II	(93, 136)
10.0‡	0.05	1.03	II	(93, 136)
15.0‡	0.05	1.19	II	(93, 136)
20 0‡	0.05	1.39	II	(93, 136)
25.0‡	0.05	1.61	II	(93, 136)
30.0‡	0.05	1.84	II	(93, 136)
18.0	0.4	1.17 ± 0.02	I	(24)
	0.6	1.18 ± 0.02		
	0.8	1.19 ± 0.02		
	1.0	1.20 ± 0.02		
	1.5	1.21 ± 0.02		
	2.0	1.23 ± 0.02		
	2.5	1.24 ± 0.02		
	3.0	1.25 ± 0.02		
20§	1.0	1.27B		(86)
30§	1.0	1.55B		

† α = 0.025 between 18 and 5°C; *cf.* (93). ‡ Interpolated. § In 2 % agar.

NaBr

t, °C	c_0 (resp. c^*)	$10^5\Delta$	Method	Lit.
8	4.0	0.9	III	(118)
10	3.7	1.0 D to E		
13	3.0	1.1		

NaI; *cf.* (59, 81)

8	1.0	0.9	III	(118)
	2.0	1.0 D to E		
13	0.086	1.13 ± 0.04	II	(77)
	0.24	1.09 ± 0.04		

$NaNO_3$; *cf.* (52, 58, 118)

3	5.5	0.66C	II, IV	(115, 116)
	1.2	0.72C		
11	3	0.89C	II, IV	(115, 116)
	2	0.94C		
	0.5	0.97C		
13	6.0	0.89C	II, IV	(115, 116)
	0.5	1.04C		
10	3.9*	0.73*E		(134)
	0.9*	0.91*E		
	0.1*	0.97*E		
	0.02*	0.98*E		
15	0.3	1.0F	II	(59)

Na_2SO_3

15	0.5	0.59F	II	(59)

Na_2SO_4;† *cf.* (59, 118, 122)

0	1.0	0.36B	V	(123)
20	1.0	0.77B	V	(123)

$Na_2S_2O_3$

10	1.1	0.62D	IV	(116)
	0.2	0.74D		

$NaHSO_4$ (59)

Diffuses as a mixture of Na_2SO_4 and H_2SO_4.

Na_2CO_3;‡ *cf.* (58)

5	0.5	0.51D	II	(115)
5	2.0	0.37E	III	(110)
9	2.4	0.43E	III	(118)
20	3.5	0.70E	III	(118)
15	0.6	0.77F	II	(59)

$Na_2C_2O_4$, Oxalate

6	0.3	0.60	II	(115)

$NaCHO_2$, Formate

8	0.4	0.80C	IV	(116)
10	0.9	0.84C		

$NaC_2H_3O_2$, Acetate; *cf.* (59, 122)

5	0.25	0.6C	II	(114)
12	0.4–0.06	0.76C	II	(78, 115)
	0.03–0.01	0.82C		
14	0.125	0.87C	II	(77)
14	0.105	0.86C	II	(81)

$Na_2C_4H_4O_6$, Tartrate

4	0.25	0.50C	II	(115)

$NaC_7H_5O_5S$, Sulfobenzoate

15	0.3	0.8C	II	(116)

† In 0.5 % agar.
‡ Hydrolyzed.

KOH;† *cf.* (34, 35, 59, 115, 140)

t, °C	c_0 (resp. c^*)	$10^5\Delta$	Method	Lit.
10.0	0.45	1.76 ± 0.02	II	(93)
	0.05	1.81 ± 0.02		
18.0	1.8	2.19 ± 0.02	II	(93)
	0.9	2.15 ± 0.02		
	0.45	2.13 ± 0.03		
	0.2	2.13 ± 0.03		
	0.1	2.15 ± 0.03		
	0.05	2.17 ± 0.04		
	0.02	2.19 ± 0.04		
	0.01	2.20 ± 0.05		
13	3.0	2.3C	II	(4)
	1.0	2.05C		
	0.75	2.05C		
	0.5	2.0C		
	0.375	2.0C		
13	4.0*	2.8*E		(134)
	1.0*	2.1*E		
	0.1*	2.0*E		
	0.02*	1.9*E		

KCl; *cf.* (34, 36, 59, 63, 67, 86, 111, 118, 122, 126, 134, 137, 140)

For Δ in solutions of various organic substances, *see* (100)

18.0	0.05*	1.55* ± 0.03		(24, 25, 26)
	0.1*	1.52* ± 0.03		
	0.2*	1.50* ± 0.03		
	0.4*	1.49* ± 0.03		
	0.6*	1.53* ± 0.03		
	0.8*	1.56* ± 0.03		
	1.0*	1.59* ± 0.03		
	1.5*	1.66* ± 0.03		
	2.0*	1.74* ± 0.03		
	2.5*	1.82* ± 0.03		
	3.0*	1.92* ± 0.03		
	3.5*	2.02* ± 0.03		
	4.0*	2.13* ± 0.03		
0	2.7‡	1.05 ± 0.03	I	(24, 61, 62)
13	2.7‡	1.39 ± 0.03	I	(24, 61, 62)
18	2.7‡	1.63 ± 0.03	I	(24, 61, 62)
24	2.7‡	1.77 ± 0.03	I	(24, 61, 62)
0	1.3‡	0.99 ± 0.03	I	(24)
15	1.3‡	1.46 ± 0.03	I	(24)
18	1.3‡	1.53 ± 0.03	I	(24)
24	1.3‡	1.79 ± 0.03	I	(24)
18.0	0.4	1.46 ± 0.03	I	(24)
	0.6	1.48 ± 0.03		
	0.8	1.49 ± 0.03		
	1.0	1.51 ± 0.03		
	1.5	1.54 ± 0.03		
	2.0	1.58 ± 0.03		
	2.5	1.62 ± 0.03		
0§	1.0	0.94A	V	(126)
20§	1.0	1.64A	V	(126)
30§	1.0	2.07A	V	(126)
40§	1.0	2.50A	V	(126)
5.0	3.6	1.09 ± 0.02	II	(93, 95, 102)
	1.0¶	1.08 ± 0.02		
	0.5¶	1.09 ± 0.02		

† $\alpha = 0.021$ between 18 and 10°C; *cf.* (93).

‡ For $c_0 = 2.7$: $\Delta_t = \Delta_0 (1 + 0.02t + 0.0005t^2)$.

For $c_0 = 1.3$: $\Delta_t = \Delta_0(1 + 0.023t + 0.00047t^2)$.

§ In 0.5 % agar.

¶ $10^5\Delta = A\{1 + 0.0242(t - 18) + 0.0001(t - 18)^2\}$, where

For c_0 =	0.1	0.25	0.5	1.0
A =	1.595	1.549	1.537	1.536

KCl.—(*Continued*)

t, °C	c_0 (resp. c^*)	$10^5\Delta$	Method	Lit.
6.0	1.8	1.10 ± 0.02	II	(93, 95, 102)
	0.25¶	1.14 ± 0.02		
7.0	0.1¶	1.18 ± 0.02	II	(93, 95, 102)
	0.05	1.20 ± 0.03		
9.0	0.02	1.28 ± 0.03	II	(93, 95, 102)
	0.01	1.30 ± 0.03		
14.0	1.0¶	1.38 ± 0.02	II	(93, 95, 102)
	0.5¶	1.38 ± 0.02		
	0.25¶	1.39 ± 0.02		
18.0	1.0¶	1.54 ± 0.01	II	(93, 95, 102)
	0.1¶	1.60 ± 0.01		
20.0	1.0¶	1.61 ± 0.02	II	(93, 95, 102)
	0.25¶	1.63 ± 0.02		
24.0	1.0¶	1.78 ± 0.02	II	(93, 95, 102)
	0.25¶	1.79 ± 0.02		
30.0	1.0¶	2.00 ± 0.02	II	(93, 95, 102)
	0.5¶	2.01 ± 0.02		
	0.25¶	2.03 ± 0.02		
20.00	0.1	1.676 ± 0.005	II	(16, 27, 31)

KBr

12	1.5	1.4D	III	(118)
	2.2	1.4D		
	2.3	1.4D		
20	1.4	1.6D	III	(118)
	3.2	1.8D		
	4.6	1.8D		

KI;† *cf.* (52, 59)

8.0	5.3	1.37 ± 0.02	II	(93)
	2.7	1.27 ± 0.02		
	0.9	1.21 ± 0.02		
	0.46	1.22 ± 0.02		
	0.18	1.22 ± 0.02		
	0.09	1.23 ± 0.02		
	0.045	1.25 ± 0.04		
	0.02	1.26 ± 0.04		
	0.01	1.29 ± 0.04		
15.0	0.46	1.46 ± 0.02	II	(93)
	0.046	1.49 ± 0.02		
9	1.4	1.3D	III	(118)
	5.4	1.6D		
16	1.1	1.5D	III	(118)
	1.4	1.5D		
	2.4	1.6D		
	4.0	1.8D		
	6.0	2.0D		
13.0	0.09	1.45 ± 0.05	II	(77)

K_2SO_3

15	0.4	0.87F	II	(59)

K_2SO_4; *cf.* (46, 47, 59, 118)

0‡	1.0	0.47C	V	(125)
20‡	1.0	0.91B	V	(125)
9	0.02*	0.9*E		(134)
20	0.95*	0.9*E		(134)
	0.25*	1.0*E		
	0.05*	1.1*E		
	0.005*	1.2*E		

† $\alpha = 0.0235$ between 15 and 8°C; *cf.* (93). ‡ In 0.5 % agar.

$KHSO_4$; (59, 134)

Diffuses as a mixture of K_2SO_4 and H_2SO_4.

KNO_3; *cf.* (52, 58, 59, 115, 118, 134)

t, °C	c_0 (resp. c^*)	$10^5\Delta$	Method	Lit.
18.0	0.05*	1.46* ± 0.02		(24, 25, 26)
	0.1*	1.43* ± 0.02		
	0.2*	1.39* ± 0.02		
	0.4*	1.34* ± 0.02		
	0.6*	1.30* ± 0.02		
	0.8*	1.27* ± 0.02		
	1.0*	1.24* ± 0.02		
	1.5*	1.19* ± 0.02		
	2.0*	1.15* ± 0.02		
	2.5*	1.17* ± 0.02		
0.0	1.0†	0.87 ± 0.03	I	(24)
	0.5†	0.89 ± 0.03	I	(24)
15.0	1.0†	1.26 ± 0.03	I	(24)
16.0	0.5†	1.29 ± 0.03	I	(24)
18.0	0.05	1.49 ± 0.02	I	(24)
	0.1	1.46 ± 0.02		
	0.2	1.43 ± 0.02		
	0.4	1.40 ± 0.02		
	0.6	1.37 ± 0.02		
	0.8	1.35 ± 0.02		
	1.0	1.33 ± 0.02		
	2.6	1.25 ± 0.02		
19.0	1.0†	1.35 ± 0.03	I	(24)
	0.5†	1.42 ± 0.03		
24.0	1.0†	1.54 ± 0.03	I	(24)
25.0	0.5†	0.55 ± 0.03	I	(24)

K_2CO_3;‡ *cf.* (58, 59)

5	10.0	0.60E	III	(118)
9	3.0	0.68E		
21	2.9	0.8E		

$KC_2H_3O_2$,‡ Acetate

14	2.0	1.01	II	(77)
	1.0	1.13		

$K_3Fe(CN)_6$

16	0.3	0.94	II	(14)
	0.3	0.46§		

$K_4Fe(CN)_6$

16	0.4	1.06	II	(14)
	0.4	0.34§		

$K_2Cr_2O_7$

12.0	0.063	0.96C	IV	(143)
	0.03	0.99C		
18.0	0.15	1.09C	IV	(143)
	0.05	1.17C		
	0.016	1.17C		
	0.007	1.24C		

† For $c_0 = 1.0$: $\Delta = 0.87(1 + 0.023t + 0.00032t^2) \times 10^{-5}$.
For $c_0 = 0.5$: $\Delta = 0.89(1 + 0.24t + 0.00027t^2) \times 10^{-5}$.
‡ Hydrolyzed.
§ In 0.1*N* KCl.

RbCl and CsCl (91)

Relative determinations; at 18°C, KCl: RbCl: CsCl = 1.00: 1.02: 1.05 (semi-quantitative).

ℭ-Table

ℭ-Arrangement (*v.* Vol. III, p. viii)

CH_2O_2, Formic acid; *cf.* (133, 140)

t, °C	c_0 (resp. c^*)	$10^5\Delta$	Method	Lit.
9	1.0	1.02C	II	(4)
15	0*	1.04*E to F		(136)

CH_4N_2O, Urea; *cf.* (13, 37, 68, 105, 116)

10.0	1.0	0.89B	II	(96)
	0.25	0.96B		
12.0	0.7	0.96B	II	(77, 78)
	0.5	0.96B		
	0.35	0.97B		
	0.25	0.97B		
	0.15	0.98B		
	0.10	0.97B		
	0.05	0.99B		
15	0*	0.94*(?)		(136)
20.0	2.0	1.14B	II	(96)
	1.0	1.14B		
	0.25	1.18B		

CH_4O, Methyl alcohol; *cf.* (104)

15	0*	1.28*C		(136)

$CH_8N_2O_3$,† Ammonium carbonate

15	0.7	1.17F	II	(59)

$C_2H_2O_4$, Oxalic acid; *cf.* (52, 140)

4	0.4	0.73D	II, IV	(114, 115)
8	0.8	0.82D	II, IV	(114, 115)
14	0.25	1.09C	II, IV	(114, 115)
	0.16	1.17C		
	0.1	1.23C		
10	1.5	0.67E	II	(4)
	0.75	0.83E		
	0.15	0.95E		
15	0*	1.1*F		(136)
20.0	2.0	0.91 ± 0.02	II	(102)
	1.5	0.98 ± 0.02		
	1.0	1.01 ± 0.02		
	0.75	1.06 ± 0.02		
	0.50	1.14 ± 0.02		
	0.25	1.26 ± 0.03		
	0.1	1.41 ± 0.03		

$C_2H_3Cl_3O_2$, Chloral hydrate

9	0.4	0.64	IV	(114)
15	0*	0.58*D		(136)

C_2H_3N, Acetonitrile

15	0*	1.26*C		(136)

$C_2H_4N_4$, Dicyanodiamide

10.0	0.25	0.77 ± 0.03	II	(96)
20.0	0.40	0.99 ± 0.04	II	(96)
	0.20	1.04 ± 0.04		

$C_2H_4O_2$,‡ Acetic acid; *cf.* (1, 104, 114, 115, 136, 140)

9	4.0	0.69		
	2.0	0.72		
	1.0	0.76	C to D	II (4)
	0.5	0.78		
	0.25	0.80		

† Hydrolyzed.
‡ $\alpha = 0.028$ between 18 and 12°C; *cf.* (94).

$C_2H_4O_2$.—(*Continued*)

t, °C	c_0 (resp. c*)	$10^5\Delta$	Method	Lit.
12.5†	1.0	0.82 ± 0.02	II	(94)
	0.5	0.84 ± 0.02		
	0.2	0.85 ± 0.02		
	0.1	0.87 ± 0.02		
	0.05	0.88 ± 0.02		
	0.02	0.89 ± 0.03		
	0.01	0.91 ± 0.04		
18.0†	1.0	0.96 ± 0.02	II	(94)
	0.1	1.03 ± 0.02		
17	0.93	0.92 ± 0.03	II	(41)
	0.65	0.94 ± 0.03		
	0.47	0.95 ± 0.03		

C_2H_5NO, Acetamide; *cf.* (104)

10.0	5.0	0.67 ± 0.03	II	(96)
	0.5	0.79 ± 0.03		
20.0	10.0	0.79 ± 0.03	II	(96)
	5.0	0.92 ± 0.03		
	2.0	1.00 ± 0.03		
	1.0	1.03 ± 0.03		
	0.5	1.04 ± 0.03		
15	0*	0.96*C		(136)

C_2H_6O, Ethyl alcohol; *cf.* (104)

10	3.75*	0.50*E		(134)
	0.75*	0.70*E		
	0.25*	0.78*E		
	0.05*	0.83*E		
15	0*	1.00*C-D		(136)
16	2.0	0.90D	II	(1)

$C_2H_7NO_2$,‡ Ammonium acetate

15	0.4	1.1F	II	(59)

$C_3H_6Cl_2O$, 1,-1′-Dichloropropyl alcohol

15	0*	0.75*C-D		(136)

C_3H_6O, Allyl alcohol

15	0*	0.90*C-D		(136)

$C_3H_6O_2$, Propionic acid; *cf.* (140)

$C_3H_7ClO_2$, 3-Chloro-1, 2-dihydroxypropane

15	0*	0.76*C-D		(136)

$C_3H_7NO_2$, Urethane

15	0*	0.80*C-D		(136)

C_3H_8O, *n*-Propyl alcohol

15	0*	0.87*C-D		(136)

$C_3H_8O_3$,§ Glycerol; *cf.* (68, 101, 104, 105)

10.0	2.0	0.56 ± 0.02	II	(96)
	1.0	0.55 ± 0.02		
	0.5	0.57 ± 0.02		
	0.25	0.61 ± 0.02		
	0.125	0.63 ± 0.02		
20.0	2.0	0.75 ± 0.03	II	(96)
	1.0	0.77 ± 0.03		
	0.5	0.78 ± 0.03		
	0.25	0.82 ± 0.03		
	0.125	0.83 ± 0.03		
15	0*	0.72*C-D		(136)

† α = 0.028 between 18 and 12°C.
‡ Hydrolyzed.
§ α = 0.033, between 20 and 10°C; *cf.* (96). For diffusion into solutions of KCl and LiCl, *v.* (101).

$C_4H_2N_2O_4$, Alloxan; *cf.* (105)

t, °C	c_0 (resp. c*)	$10^5\Delta$	Method	Lit.
10.0	1.0	0.48 ± 0.02	II	(96)
	0.25	0.49 ± 0.03		
20.0	1.0	0.61 ± 0.03	II	(96)
	0.5	0.64 ± 0.03		
	0.25	0.65 ± 0.03		
	0.125	0.66 ± 0.03		

$C_4H_6O_4$, Succinic acid; *cf.* (114)

20.0	1.0	0.70 ± 0.03	II	(102)
	0.75	0.73 ± 0.03		
	0.5	0.76 ± 0.03		
	0.25	0.79 ± 0.03		
	0.1	0.82 ± 0.04		

$C_4H_6O_6$, Tartaric acid; *cf.* (52, 105, 114, 116, 140)

3	0.25	0.41D	II	(115)
5	0.25	0.43D	II	(115)
	0.7	0.43D		
9	0.7	0.52D	II	(115)
15	0*	0.61*C-D		(136)
18	6.0*	0.34*E		(134)
	2.45*	0.50*E		
	0.95*	0.57*E		
	0.35*	0.62*E		
	0.1*	0.64*E		
	0.0125*	0.66*E		

$C_4H_6O_6$, *dl*-Tartaric acid

5	0.7	0.45D	II	(115, 116)
	0.2	0.44D		

$C_4H_8O_2$, *n*-Butyric acid (140)

$C_4H_{10}O$, *n*-Butyl alcohol

15	0*	0.77*C-D		(136)

C_5H_5N, Pyridine

15	0*	0.58*C-D		(136)

$C_5H_{10}O_5$, Arabinose

9.0	0.5	0.41 ± 0.02	II	(94)
	0.25	0.44 ± 0.02		
	0.1	0.46 ± 0.02		
20.0	0.5	0.64 ± 0.03	II	(94)
	0.1	0.69 ± 0.03		

$C_5H_{12}O$, Isoamyl alcohol

15	0*	0.69*C-D		(136)

$C_5H_{12}O_4$, Pentaerythritol

10.0	0.4	0.47 ± 0.02	II	(96)
	0.2	0.49 ± 0.02		
20.0	0.4	0.67 ± 0.02	II	(96)
	0.2	0.68 ± 0.02		

$C_6H_3N_3O_7$, Picric acid; *cf.* (45)

15	0*	0.69*C-D		(136)

C_6H_6O, Phenol

12	<0.2*	0.64*(?)		(136)
16	<0.2*	0.74*(?)		(136)
20	<0.2*	0.84*(?)		(136)

$C_6H_6O_2$, Hydroquinol

15	0*	0.66*C-D		(136)
20.0	0.7	0.74 ± 0.02	II	(96)
	0.5	0.76 ± 0.02		
	0.25	0.77 ± 0.02		

$C_6H_6O_2$, Resorcinol

t, °C	c_0 (resp. c^*)	$10^5\Delta$	Method	Lit.
10	1.0	0.51 ± 0.02	II	(96)
	0.25	0.53 ± 0.02		
20	2.0	0.61 ± 0.02	II	(96)
	1.0	0.69 ± 0.02		
	0.5	0.72 ± 0.02		
	0.25	0.75 ± 0.03		
	0.125	0.76 ± 0.03		
15	0*	0.65*C-D		(136)

$C_6H_6O_3$, Pyrogallol

15	0*	0.56*C-D		(136)

$C_6H_8O_7$, Citric acid; *cf.* (140)

5	0.3	0.39D	II	(114, 115)
9	1.1	0.48D	II	(114, 115)

$C_6H_{12}N_4$, Hexamethylenetetramine

21	0.6	0.6	II	(104)

$C_6H_{12}O_6$, Glucose

15	0*	0.52*C-D		(136)

$C_6H_{14}O_6$, Mannitol; *cf.* (37, 114)

0†	0.3	0.26 ± 0.02	IV	(117)
10†	0.3	0.40 ± 0.02	IV	(117)
20†	0.3	0.56 ± 0.02	IV	(117)
30†	0.3	0.72 ± 0.03	IV	(117)
40†	0.3	0.90 ± 0.04	IV	(117)
50†	0.3	1.10 ± 0.04	IV	(117)
60†	0.3	1.32 ± 0.05	IV	(117)
70†	0.3	1.56 ± 0.06	IV	(117)
10.0	0.5	0.39 ± 0.02	II	(96)
	0.25	0.40 ± 0.02		
	0.125	0.42 ± 0.02		
20.0	0.5	0.53 ± 0.02	II	(96)
	0.25	0.56 ± 0.02		
	0.125	0.58 ± 0.02		
15	0*	0.50*C-D		(136)

$C_7H_6O_5$, Gallic acid (105)

$C_7H_8O_2$, *o*-Hydroxybenzyl alcohol

20.0	1.0	0.60 ± 0.02	II	(96)
	0.5	0.67 ± 0.03		
	0.25	0.72 ± 0.03		

$C_8H_{10}N_4O_2$, Caffeine

10.0	0.05	0.41 ± 0.03	II	(94)

$C_9H_{15}NO_3$, Ecgonine

20.0	1.0	0.61 ± 0.03	II	(96)
	0.5	0.66 ± 0.03		
	0.1	0.70 ± 0.03		

$C_{10}H_{14}N_2$, Nicotine

10.0	1.0	0.28 ± 0.02	II	(94)
	0.5	0.37 ± 0.02		
	0.1	0.46 ± 0.02		
20.0	1.0	0.32 ± 0.02	II	(94)
	0.5	0.43 ± 0.02		
	0.1	0.53 ± 0.04		

$C_{12}H_{22}O_{11}$, Lactose

10.0	0.2	0.32 ± 0.02	II	(94)
	0.1	0.32 ± 0.02		
20.0	0.2	0.41 ± 0.02	II	(94)
	0.1	0.43 ± 0.02		
15	0*	0.38*D		(136)

† Interpolated.

$C_{12}H_{22}O_{11}$, Maltose; *cf.* (105)

t, °C	c_0 (resp. c^*)	$10^5\Delta$	Method	Lit.
10.0	0.5	0.29 ± 0.01	II	(94)
	0.25	0.31 ± 0.02		
	0.1	0.32 ± 0.02		
20.0	0.5	0.38 ± 0.01	II	(94)
	0.25	0.41 ± 0.02		
	0.1	0.42 ± 0.02		
15	0*	0.38*D		(136)

$C_{12}H_{22}O_{11}$,† Saccharose; *cf.* (4, 104, 105, 122)

12.0	2.0	0.25	±0.01 to 0.02		(94, 102)
	1.5	0.28			
	1.0	0.30			
	0.5	0.325			
	0.25	0.34			
	0.1	0.35			
	0.075	0.355			
14.0	1.0	0.33			
	0.5	0.35			
	0.25	0.36			
20.0	2.0	0.32			
	1.0	0.38			
	0.5	0.41			
	0.25	0.43			
24.0	1.0	0.435			
	0.25	0.49			
29.0	1.0	0.50			
	0.5	0.53			
	0.25	0.55			
15	0*	0.38*D			(136)
18	2.0*	0.15*E			(134)
	1.0*	0.28*E			
	0.3*	0.36*E			
	0.005*	0.38*E			

$C_{13}H_{18}O_7$, Salicin

20.0	0.12	0.46 ± 0.03	II	(96)
	0.06	0.49 ± 0.03		

$C_{14}H_{10}O_9$, Tannin (105, 122)

$C_{18}H_{32}O_{16}$, Raffinose; *cf.* (105)

11.0	0.25	0.27	±0.01	II	(94)
	0.125	0.27			
	0.1	0.28			
	0.075	0.28			
	0.05	0.28			
20.0	0.25	0.33	±0.01 to 0.02	II	(94)
	0.1	0.36			
	0.05	0.36			
15	0*	0.33*E			(136)

Colloids

Only the order of magnitude has significance

Amylum (Starch)

20	5%‡	0.067		(96)
	2.5%‡	0.072		
	1.25%‡	0.08		
	5–8%§	0.24(?)		

† $\Delta_t = \Delta_{20}(1 + 0.029(t - 20) + 0.0005(t - 20)^2)$.

‡ Powder-like.

§ Dough-like.

Colloids.—(*Continued*)

Inulin

t, °C	c_0 (resp. c^*)	$10^5\Delta$	Method	Lit.
20	0.01(?)	0.16		(96)
Dextrin; *cf.* (105)				
10	1.0	0.079		(96)
	0.5	0.081		
	0.25	0.088		
	0.1	0.090		
	0.075	0.090		
20	1.0	0.11		(96)
	0.5	0.12		
	0.25	0.12		
	0.125	0.12		
Gum arabic; *cf.* (122)				
20	5%	0.23		(96)
	2.5%	0.24		

For several proteins and ferments, *v.* (37, 69, 79, 122).

NON-AQUEOUS SOLUTIONS

DIFFUSION IN METHYL ALCOHOL

A-B-Table

I_2

t, °C	c_0	$10^5\Delta$	Method	Lit.
9	0.1	1.52A	II	(90)
20	0.1	1.82A		
LiCl				
14	0.65	0.75		
	0.25	0.85	B to C	II (81)
	0.15	0.92		
	0.07	0.92		
NaI				
14	0.2	1.00		
	0.15	1.02	B to C	II (81)
	0.07	1.03		
$NaC_2H_3O_2$, Acetate				
14	0.3	0.84C	II	(81)
	0.2	0.87C		
	0.1	0.91C		
KI				
14	0.25	1.11		
	0.15	1.09	B to C	II (81)
	0.05	1.15		
$KC_2H_3O_2$, Acetate				
14	0.3	0.86C	II	(81)
	0.2	0.85C		
	0.1	0.97C		

C-Table, Values of $10^5\Delta$†

CCl_4, Carbon tetrachloride: 1.70* (136).

$CHBr_3$, Bromoform: 1.57*; 20°, $c_0 = 1.0$, $10^5\Delta = 1.89 \pm 0.04$; $c_0 = 0.5$, $10^5\Delta = 1.93 \pm 0.06$ (98).

$CHCl_3$, Chloroform: 2.07* (136).

CHI_3, Iodoform: 1.33* (136).

CH_2ClBr, Chlorobromomethane: 2.50* (136).

CH_2I_2, Methylene iodide: 1.68* (136).

CH_2O_2, Formic acid: 1.92* (136).

CH_3NO_2, Nitromethane: 16°, $c_0 = 3.3$, $10^5\Delta = 2.53$D (39).

CH_4N_2O, Urea: 1.24* (136).

† Unless otherwise stated, the temperature is 15°C, $c^* = ca.$ 1% and the reliability of Δ is probably D, E or F in all determinations by Thovert (136).

C_2HBr_3O, Bromal: 0.72* (136).

$C_2HBr_3O_2$, Tribromoacetic acid: 1.23* (136).

$C_2HCl_3O_2$, Trichloroacetic acid: 1.45* (136).

$C_2H_2Cl_2O_2$, Dichloroacetic acid: 1.36* (136).

$C_2H_2O_4$, Oxalic acid: 1.46* (136).

$C_2H_3BrO_2$, Bromoacetic acid: 1.33* (136).

$C_2H_3ClO_2$, Chloroacetic acid: 1.52* (136).

$C_2H_3Cl_3O_2$, Chloral hydrate: 1.16* (136).

C_2H_3N, Acetonitrile: 2.64* (136).

$C_2H_4Br_2$, Ethylene bromide: 1.95* (136).

$C_2H_4Cl_2$, Ethylene chloride: 2.21* (136).

$C_2H_4I_2$, Ethylene iodide: 1.56* (136).

$C_2H_4O_2$, Acetic acid: 1.54* (136).

C_2H_5Br, Ethyl bromide: 2.40* (136).

C_2H_5I, Ethyl iodide: 2.16* (136).

C_2H_5NO, Acetamide: 1.50* (136).

$C_2H_5NO_3$, Ethyl nitrate: 2.20* (136).

C_3H_5Br, 3-Bromopropylene 2.22* (136).

$C_3H_5BrO_2$, Bromopropionic acid: 1.35* (136).

$C_3H_5Cl_3$, 1, 2, 3-Trichloropropane: 1.76* (?) (136).

C_3H_5I, 3-Iodopropylene: 1.72* (136).

$C_3H_5IO_2$, Iodopropionic acid: 1.36* (136).

$C_3H_6Cl_2O$, 1, 1′-Dichlorohydrin: 1.36* (136).

C_3H_6O, Allyl alcohol: 1.80* (136).

C_3H_6O, Acetone: 19°, $c_0 = 3.4$, $10^5\Delta = 2.57$D (39).

$C_3H_6O_2$, Propionic acid: 1.62* (136).

$C_3H_6O_3$, Lactic acid: 1.36* (136).

$C_3H_7ClO_2$, 1-Chlorohydrin: 1.30* (136).

$C_3H_7NO_2$, Urethane: 1.41* (136).

$C_3H_8O_2$, Propylene glycol: 1.24* (136).

$C_3H_8O_3$, Glycerol: 1.15* (136).

$C_4H_5Cl_3O_2$, Ethyl trichloroacetate: 1.44* (136).

$C_4H_6O_6$, Tartaric acid: 0.94* (136).

$C_4H_7ClO_2$, Ethyl chloroacetate: 1.77* (136).

$C_4H_8O_2$, Ethyl acetate: 2.10* (136); 18°, $c_0 = 2.3$, $10^5\Delta = 2.0$D (39).

$C_4H_{10}O$, Ethyl ether: 2.00* (136).

$C_4H_{10}O_4S$, Diethyl sulfate: 1.56* (136).

$C_4H_{16}N_2O_4S$, Ethylamine sulfate: 0.92* (136).

$C_5H_4N_4O_3$, Uric acid: 1.79* (136).

$C_5H_4O_2$, Furfural: 1.70* (136).

C_5H_5N, Pyridine: 1.58* (136); 15°, $c_0 = 0.5$, $10^5\Delta = 1.64 \pm 0.06$, $c_0 = 0.2$, $10^5\Delta = 1.56 \pm 0.06$ (129).

$C_5H_{10}I_2$, 2, 3-Diiodopentane: 1.57* (136).

$C_5H_{11}I$, Isoamyl iodide: 1.76* (136).

$C_5H_{12}O$, Isoamyl alcohol: 1.34* (136).

C_6Cl_6, Hexachlorobenzene: 1.31* (136).

$C_6H_2Cl_4$, Tetrachlorobenzene: 1.49* (136).

$C_6H_3Br_3$, Tribromobenzene: 1.49* (136).

$C_6H_3Br_3O$, 2, 4, 6-Tribromophenol: 1.12* (136).

$C_6H_3Cl_3O$, 2, 4, 6-Trichlorophenol: 1.21* (136).

$C_6H_3N_3O_7$, 2, 4, 6-Trinitrophenol: 1.32* (136).

$C_6H_4BrNO_2$, Bromonitrobenzene: 1.43* (136).

$C_6H_4Br_2$, *p*-Dibromobenzene: 1.55* (136).

$C_6H_4ClNO_2$, Chloronitrobenzene: 1.68* (136).

$C_6H_4Cl_2$, *p*-Dichlorobenzene: 1.80* (136).

$C_6H_4N_2O_4$, *m*-Dinitrobenzene: 1.56* (136).

$C_6H_4N_2O_5$, 2, 4-Dinitrophenol: 1.40* (136).

$C_6H_4O_2$, Quinone: 1.84* (136).

C_6H_5Br, Bromobenzene: 1.75* (136).

C_6H_5BrO, Bromophenol: 1.34* (136).

C_6H_5Cl, Chlorobenzene: 2.07* (136).

C_6H_5ClO, Chlorophenol: 1.32* (136).

C_6H_5I, Iodobenzene: 1.65* (136).

$C_6H_5NO_2$, Nitrobenzene: 1.81* (136); 16°, $c_0 = 0.8$, $10^5\Delta = 1.7$D (39).

$C_6H_5NO_3$, Nitrophenol: 1.38* (136).
C_6H_6, Benzene: 15°, for c_0 = 2.0, 1.0 and 0.5, $10^5\Delta$ = 2.12 ± 0.08, 2.22 ± 0.08 and 2.20 ± 0.08, resp. (II) (129).
C_6H_6BrN, Bromoaniline: 1.41* (136).
C_6H_6ClN, Chloroaniline: 1.37* (136).
$C_6H_6N_2O_2$, *m*-Nitroaniline: 1.14* (136).
C_6H_6O, Phenol: 1.4* (136).
$C_6H_6O_2$, Hydroquinol: 1.25* (136).
$C_6H_6O_3$, Pyrogallol: 1.08* (136).
C_6H_7N, Aniline: 1.49* (136).
C_6H_8ClN, Aniline hydrochloride: 1.19* (136).
$C_6H_{12}Cl_2O_2$, Dichloroacetal: 1.63* (136).
$C_6H_{13}ClO_2$, Chloroacetal: 1.47* (136).
$C_6H_{14}O_2$, Acetal: 1.96* (136).
$C_7H_5ClO_2$, Chlorobenzoic acid: 1.29* (136).
$C_7H_5NO_3$, *m*-Nitrobenzaldehyde: 1.24* (136).
$C_7H_5NO_4$, Nitrobenzoic acid: 1.15* (136).
C_7H_6O, Benzaldehyde: 1.66* (136).
$C_7H_6O_2$, Salicyl aldehyde: 1.75* (136).
$C_7H_6O_2$, Benzoic acid: 1.31* (136).
$C_7H_6O_3$, Salicylic acid: 1.21* (136).
$C_7H_6O_5$, Gallic acid: 0.76* (136).
C_7H_8O, Anisole: 1.96* (136).
C_7H_9N, Benzylamine: 1.21* (136).
$C_7H_{14}O_2$, Isoamyl acetate: 1.60* (136).
$C_8H_6O_4$, Phthalic acid: 1.30* (136).
$C_8H_8O_2$, Phenyl acetate: 1.62* (136).
$C_8H_8O_2$, Anisaldehyde: 1.50* (136).
$C_8H_8O_3$, Vanillin: 1.00* (136).
$C_8H_8O_3$, Methyl salicylate: 1.56* (136).
C_8H_9NO, Acetanilide: 1.50* (136).
$C_8H_{10}N_2O$, Acetylphenylhydrazine: 1.04* (136).
$C_8H_{10}O$, Xylenol: 1.33* (136).
$C_8H_{10}O$, Phenetole: 1.88* (136).
C_9H_7N, Quinoline: 1.26* (136); 15°, c_0 = 0.5, $10^5\Delta$ = 1.34 ± 0.06, c_0 = 0.2, $10^5\Delta$ = 1.29 ± 0.06 (129).
$C_9H_{10}O_2$, Ethyl benzoate: 16°, c_0 = 0.7; $10^5\Delta$ = 1.4E (39).
$C_9H_{11}NO$, Acettoluide: 1.03* (136).
$C_{10}H_6Br_2$, Dibromonaphthalene: 1.33* (136).
$C_{10}H_6Cl_2$, Dichloronaphthalene: 1.52* (136).
$C_{10}H_6N_2O_4$, Dinitronaphthalene: 1.32* (136).
$C_{10}H_7Br$, α-Bromonaphthalene: 1.29* (136).
$C_{10}H_7Cl$, α-Chloronaphthalene: 1.38* (136).
$C_{10}H_7NO_2$, α-Nitronaphthalene: 1.50* (136).
$C_{10}H_8$, Naphthalene: 15°, c_0 = 0.2, $10^5\Delta$ = 1.60 ± 0.07 (II) (129).
$C_{10}H_8O$, α-Naphthol: 1.10* (136).
$C_{10}H_{12}O$, Cumaldehyde: 1.50* (136).
$C_{10}H_{14}O$, Thymol: 1.20* (136).
$C_{11}H_{12}N_2O$, Antipyrine: 1.02* (136).
$C_{12}H_{10}$, Diphenyl: 15°, c_0 = 0.2, $10^5\Delta$ = 1.56 ± 0.07 (II) (129).
$C_{13}H_{10}O_3$, Salol: 1.29* (136).
$C_{14}H_{13}NO$, Acetyldiphenylamine: 0.98* (136).
$C_{14}H_{15}N$, Dibenzylamine: 0.84* (136).
$C_{19}H_{16}$, Triphenylmethane: 15°, c = 0.05, $10^5\Delta$ = 0.88 ± 0.05 (II) (129).
$C_{19}H_{19}N_3O$, Pararosaniline: 1.09* (136).
$C_{20}H_{14}O_4$, Phenolphthalein: 0.78* (136).

DIFFUSION IN ETHYL ALCOHOL

A-B-Table

Rn

t, °C	*c**	$10^5\Delta$	Method	Lit.
18	0*	2.7*(?)		(112)

HCl; for diffusion in dilute alcohol, *v.* (4)

I_2

t, °C	c_0 (resp. *c**)	$10^5\Delta$	Method	Lit.
8.0	0.50	0.84	II	(80)
	0.25	0.88		
	0.10	0.90		
18.0	0.25	1.10	II	(80)

CO_2

17	0*	3.2*C-D		(120)

For other C-compounds, *v.* the C-Table *infra.*

$HgCl_2$

10	0.25	0.64		(130)
	0.25	0.40 (in 73 % alcohol)		
	0.25	0.29 (in 44 % alcohol)		
	0.25	0.30 (in 27 % alcohol)		
	0.25	0.52 (in 9 % alcohol)		
	0.25	0.66 (in 2.5 % alcohol)		

$AgNO_3$

14	0.1	0.41 ± 0.02	II	(77)
	0.07	0.41 ± 0.02		

$Ca(NO_3)_2$

14	0.25	0.32 ± 0.02	II	(77)

LiCl

14	0.5	0.31 ± 0.02	II	(77, 81)
	0.3	0.34 ± 0.02		
	0.15	0.42 ± 0.02		
20	0.43	0.36 ± 0.02	II	(77, 81)

NaOH; NaCl; for diffusion in dilute alcohol, *v.* (4)

NaI

7	0.2	0.35 ± 0.03	II	(77, 81)
14	0.2	0.41 ± 0.03	II	(77, 81)
	0.1	0.44 ± 0.03		

$NaC_2H_3O_2$, Acetate

12	0.12	0.35 ± 0.02	II	(77, 81)
14	0.1	0.38 ± 0.02	II	(77, 81)

$C_{20}H_{8-x}Br_4O_5Na_x$, Eosin

20	0.005	0.31 ± 0.04	II	(97)
	0.0025	0.27 ± 0.02		

KI

14	0.09–0.03	0.47 ± 0.03	II	(77, 81)

$KC_2H_3O_2$, Acetate

14	0.25	0.38 ± 0.02	II	(77)
	0.20	0.39 ± 0.02		
	0.15	0.43 ± 0.03		

C-Table (All Data are by Method II and from (97) Except as Otherwise Indicated)

$CHBr_3$, Bromoform

t, °C	c_0	$10^5\Delta$
11	1.0	0.77C
	0.5	0.80C
20	1.0	0.96C
	0.5	0.97C

$CHCl_3$, Chloroform

11	1.0	1.19(?)
20	2.0	1.25B
	1.0	1.24B

CH_4N_2O, Urea

12	0.4	0.54 ± 0.02†

† Method II (78).

C_2HCl_3O, Chloral (in 96 % alcohol)

t, °C	c_0	$10^5\Delta$
20	2.0	0.57C
	1.0	0.61C

C_2H_5NO, Acetamide (in 96 % alcohol)

11	5.0	0.39C
	2.0	0.41C
	1.0	0.44C
20	5.0	0.52C
	2.0	0.56C
	1.0	0.61C

C_3H_6O, Allyl alcohol

t, °C	c_0	$10^5\Delta$	
20	4.0	0.91C	
	2.0	0.94C	
	1.0	0.96C	

$C_3H_8O_3$, Glycerol (in 96% alcohol)

11	2.0	0.26	C to D
	1.0	0.32	
	0.5	0.36	
20	4.0	0.27	
	2.0	0.35	
	1.0	0.41	
	0.5	0.49	
	0.25	0.50	

C_5H_5N, Pyridine

20	2.0	1.15B	
	1.0	1.14B	
	0.5	1.12B	

$C_5H_{10}O_4$, Monoacetin

20	4.0	0.38C	
	2.0	0.46C	
	1.0	0.51C	
	0.5	0.52C	
	0.25	0.54C	

$C_5H_{12}O$, Isoamyl alcohol

20	6.0	0.64C	
	4.0	0.69C	
	2.0	0.74C	
	1.0	0.78C	

C_6H_5I, Iodobenzene

20	1.0	0.94A-B	
	0.5	0.95A-B	
	0.25	0.98A-B	

C_6H_6O, Phenol‡

10	0.1*	0.64*D	
15	0.1*	0.71*D	
20	0.1*	0.80*D	

$C_6H_6O_2$, Hydroquinol (in 96% alcohol)

20	1.0	0.47C	
	0.5	0.48C	
	0.25	0.48C	

$C_6H_6O_2$, Resorcinol (in 96% alcohol)

10	2.0	0.30C	
	1.0	0.30C	
	0.25	0.31C	

‡ (136); values for c^*.

$C_6H_6O_2$.—(*Continued*)

t, °C	c_0	$10^5\Delta$	
20	2.0	0.40C	
	1.0	0.41C	

$C_6H_{14}O_2$, Acetal

20	2.0	1.13C	
	1.0	1.13C	

$C_7H_8O_2$, *o*-Hydroxybenzyl alcohol

20	1.0	0.52C	
	0.5	0.56C	
	0.25	0.59C	

$C_{10}H_7Br$, α-Bromonaphthalene (in 96% alcohol)

11	1.0	0.52	B to C
	0.5	0.59	
20	1.0	0.69	
	0.5	0.76	

$C_{10}H_{16}O$, Camphor (in 96% alcohol)

10	2.0	0.47C	
	1.0	0.52C	
20	2.0	0.62C	
	1.0	0.66C	
	0.5	0.68C	

$C_{12}H_{10}N_2$, Azobenzene (in 96% alcohol)

10	0.1	0.57C	
20	0.1	0.74C	

$C_{16}H_{34}O$, Cetyl alcohol (in 96% alcohol)

20	1.0	0.35C-D	

$C_{18}H_{36}O_2$, Stearic acid

20	0.7	0.40C	
	0.4	0.47C	
	0.2	0.58C	

$C_{22}H_{20}O_{13}$, Carminic acid (in 96% alcohol)

20	0.06	0.14E	
	0.03	0.17E	

$C_{23}H_{26}N_2O_4$, Brucine

20	0.125	0.27C	
	0.062	0.28C	

$C_{23}H_{25}N_3$, Trimethylrosaniline

20	0.02	0.67(?)	
	0.01	0.93(?)	

$C_{34}H_{47}NO_{11}$, Aconitine

20	0.04	0.27D	

DIFFUSION IN BENZENE

A-B-Table

Rn

t, °C	c_0 (resp. c^*)	$10^5\Delta$	Method	Lit.
18	0*	2.36*D		(112)

Br_2

12	0.1	2.0		(42)

I_2; *cf.* (42)

t, °C	c_0 (resp. c^*)	$10^5\Delta$	Method	Lit.
6	0.25	1.46B	II	(80)
	0.1	1.47B		
20	0.1	1.93B		(80)
	0.05	1.95B		
9	0.1	1.62B	II	(90)

C-Table, Values of $10^5\Delta$†

$CHBr_3$, Bromoform: 1.62* (136); 18°, $c_0 = 1.0$, $10^5\Delta = 1.62 \pm 0.05$ (98).

$CHCl_3$, Chloroform: 2.11* (136).

CHI_3, Iodoform: 1.38* (136).

CH_2O_2, Formic acid: 2.16* (136).

$C_2H_3ClO_2$, Chloroacetic acid: 1.48* (136).

$C_2H_4Br_2$, Ethylene bromide: 1.97* (136).

$C_2H_4Cl_2$, Ethylene chloride: 2.45* (136).

$C_2H_4I_2$, Ethylene iodide: 1.40* (136).

$C_2H_4O_2$, Acetic acid: 1.92* (136).

$C_3H_5Cl_3$, 1, 2, 3-Trichloropropane: 1.72* (136).

C_3H_8O, Propyl alcohol: 1.60* (136).

$C_4H_{10}O$, Ethyl ether: 2.21* (136).

$C_5H_{12}O$, Isoamyl alcohol: 1.48* (136).

$C_6H_3N_3O_7$, 2, 4, 6-Trinitrophenol: 1.39* (136).

$C_6H_4BrNO_2$, Bromonitrobenzene: 1.33* (136).

$C_6H_4Br_2$, *p*-Dibromobenzene: 1.37* (136).

$C_6H_4ClNO_2$, Chloronitrobenzene: 1.70* (136).

$C_6H_4Cl_2$, *p*-Dichlorobenzene: 1.90* (136).

$C_6H_4N_2O_4$, *m*-Dinitrobenzene: 1.54* (136).

$C_6H_4O_2$, Quinone: 1.68* (136).

C_6H_5Br, Bromobenzene: 1.86* (136).

C_6H_5BrO, Bromophenol: 1.34* (136).

C_6H_5Cl, Chlorobenzene: 2.15* (136).

C_6H_5ClO, Chlorophenol: 1.42* (136).

C_6H_5I, Iodobenzene: 1.50* (136).

$C_6H_5NO_2$, Nitrobenzene: 1.84* (136).

C_6H_6BrN, Bromoaniline: 1.41* (136).

C_6H_6ClN, Chloroaniline: 1.56* (136).

C_6H_6O, Phenol†

t, °C	$10^5\Delta$	Lit.
5	1.27*	(136)
10	1.39*	
15	1.54*	
20	1.68*	
25	1.84*	

C_7H_6O, Benzaldehyde: 1.73* (136).

$C_7H_6O_2$, Salicylaldehyde: 1.78* (136).

$C_7H_6O_2$, Benzoic acid: 1.36* (136).

$C_8H_6O_4$, Phthalic acid: 1.37* (136).

$C_8H_8O_3$, Methyl salicylate: 1.56* (136).

$C_{10}H_6Br_2$, Dibromonaphthalene: 1.25* (136).

$C_{10}H_6Cl_2$, Dichloronaphthalene: 1.40* (136).

$C_{10}H_6N_2O_4$, Dinitronaphthalene: 1.23* (136).

$C_{10}H_7Br$, α-Bromonaphthalene: 1.30* (136).

$C_{10}H_7Cl$, α-Chloronaphthalene: 1.20* (136).

$C_{10}H_7NO_2$, α-Nitronaphthalene: 1.39* (136).

$C_{10}H_8$, Naphthalene: 24°, $c_0 = 1.3$, $10^5\Delta = 1.22$F (104).

$C_{10}H_{12}O_2$, Thymoquinone: 1.20* (136).

$C_{12}H_{10}$, Diphenyl: 26°, $c_0 = 0.5$, $10^5\Delta = 1.17$F (104).

$C_{14}H_{13}NO$, Acetyldiphenylamine: 0.90* (136).

$C_{14}H_{14}$, Dibenzyl: 26°, $c_0 = 0.4$, $10^5\Delta = 1.00$F (104).

† Unless otherwise stated, the temperature is 15°C, $c^* = ca.$ 1% and all values of $10^5\Delta$ have a reliability D, E or F in all determinations by Thovert (136).

DIFFUSION IN METALS, *v. also* (88, 89, 146) *and* p. 77

Solvent	Solute	t, °C	c_0 (resp. c^*)	$10^5\Delta$	Lit.
Bi	Au	555	(?)	5.2	(109)
Hg	Au	11	(?)	0.8	(109); *cf.* (88, 89, 146)
	Cd	20.0	0*	1.52_0* $\pm 0.01_5$	(29, 32)
		20.0	0*	1.44_6* $\pm 0.01_5$‡	(30, 33)
Pb	Au	492	*ca.* 30 %	3.5	(109)
		550	*ca.* 30 %	3.7	(109)
	Pt	492	(?)	1.9_6	(109)
	Rh	550	(?)	3.5	(109)
	Th-B	340	0*	2.5*	(64)
Sn	Ag	555	(?)	4.8	(109)
	Au	555	(?)	5.4	(109)
	Pb	555	(?)	3.7	(109)

‡ At 1500 atm.

DIFFUSION IN VARIOUS LIQUIDS, *v. also* (39)

Rn

Solvent	t, °C	c_0 (resp. c^*)	$10^5\Delta$	Method	Lit.
C_7H_8, Toluene	18	0*	2.7*D		(112)

Br_2

CS_2	16	0.1	3.6		(42)

I_2

CCl_4	8	0.1	1.1_1	II	(90)
	20	0.1	1.3_6	II	(90)
CS_2	8	0.25	2.75	II	(42, 80, 90)
		0.10	2.7_8		(80)
		0.05	2.7_9		(80)
	10	0.05	2.8_7	II	(80)
	16	0.1	2.9_5	II	(80)
	20	0.1	3.1_2	II	(80)
$CHCl_3$	10	0.1	1.8_6	II	(80, 90)
		0.05	1.9_3		
	20	0.1	2.1_2	II	(80, 90)
$C_2H_2Br_4$, 1, 1, 2, 2- Tetrabromoethane	11	0.1	0.13_4	II	(90)
	20	0.1	0.18_8	II	(90)
$C_2H_4Br_2$, Ethylene bromide	12	0.1	0.72	II	(90)
	20	0.1	0.8_8	II	(90)
$C_2H_4O_2$, Acetic acid	20	0.1	1.0_3	II	(90)
$C_4H_8O_2$, Ethyl acetate	9	0.1	1.87	II	(90)
	20	0.1	2.1_5	II	(90)
$C_4H_{10}O$, Ethyl ether	7	0.5	2.65	II	(80)
		0.25	2.7_3		
		0.1	2.8_4		
C_6H_5Br, Bromobenzene	9	0.1	1.0_2	II	(90)
	20	0.1	1.2_0	II	(90)
C_7H_8, Toluene	9	0.1	1.6_7	II	(90)
	20	0.1	1.95	II	(90)
C_7H_8O, Anisole	8	0.1	0.8_8	II	(90)
	20	0.1	1.1_3	II	(90)
$C_7H_{14}O_2$, Isoamyl acetate	9	0.1	1.0_1	II	(90)
	20	0.1	1.2_4	II	(90)
C_7H_{16}, Heptane	9	0.1	2.3_6	II	(90)
	20	0.1	2.6_7	II	(90)
C_8H_{10}, *m*-Xylene	9	0.1	1.4_2	II	(90)
	20	0.1	1.6_8	II	(90)
$C_8H_{10}O$, Phenetole	8	0.1	0.7_7	II	(90)
	20	0.1	0.9_8	II	(90)

$CHBr_3$

C_3H_6O, Acetone	20	1.0	2.64	II	(98)
		0.5	2.6_9		
		0.25	2.7_1		
C_3H_8O, *n*-Propyl alcohol	17	1.0	0.7_1	II	(98)
$C_4H_{10}O$, Ethyl ether	17	1.0	3.1_4	II	(98)
		0.5	3.2_4		
		0.25	3.2_1		
$C_5H_{12}O$, Isoamyl alcohol	17	1.0	0.47	II	(98)

DIFFUSION IN VARIOUS LIQUIDS.—(*Continued*)

$C_2H_2Br_4$, 1, 1, 2, 2-Tetrabromoethane

Solvent	t, °C	c_0 (resp. c^*)	$10^5\Delta$	Method	Lit.
$C_2H_2Cl_4$, 1, 1, 2, 2- Tetrachloroethane	0.0	0.06	0.35	II	(28)
	10.0	0.06	0.45		
	15.0	0.06	0.50		
	25.0	0.06	0.61		
	35.0	0.06	0.73		
	50.0	0.06	0.94		

(± 0.01 to 0.02)

$C_3H_8O_3$, Glycerol

C_3H_8O, *n*-Propyl alcohol	18	1.0	2.38	II	(98)
$C_5H_{12}O$, Isoamyl alcohol	18	1.0	0.1_1	II	(98)

C_6H_6O, Phenol

CS_2	19	0*	3.4*		(136)
$CHCl_3$	10	0*	1.6*		(136)
$C_4H_{10}O$, Ethyl ether	19	0*	3.6*		(136)
$C_5H_{12}O$, Isoamyl alcohol	19	0*	0.2*		(136)

For diffusion in anistropic liquids, *v.* (128).

LITERATURE

(For a key to the periodicals see end of volume)

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PERMEABILITY OF SOLIDS TO GASES

FRANK PORTER

By the permeability of a solid is meant the quantity K in the equation $\frac{dm}{dt} = -K\rho_o \frac{\Delta p}{\Delta z}\,dx dy$, where dm is the mass of gas which passes in the direction of z and in time dt through a diaphragm of the solid of area $dx dy$ and thickness Δz, the difference in pressure on the two sides of the diaphragm (excess on positive side) being Δp; the $-$ sign indicates that the flow is in the direction of decreasing pressure. ρ_o is the density of the gas at 0°C and pressure $= A_n$; dm/ρ_o = volume of dm at 0°C and A_n. At very low pressures K may depend upon the pressure (12). The passage of a gas through a porous septum is approximately given by $\frac{dm}{dt} = -K_o \sqrt{\rho_o}\frac{\Delta p}{\Delta z}\,dx dy$ (11), where K_o is independent of the nature of the gas. In the table, l denotes that the value given is for water vapor when one surface of the diaphragm is in contact with liquid water.

Unit of p = 1 atm.; of θ = 1°C; of K (metals and rubber) = 10^{-6} cm²/(atm.-sec); of K (glass) = 10^{-9} cm²/(atm.-sec).

METALS*

H-Cu

θ	K	Lit.
500	3.5	(1)
750	8	

H-Fe

200	0.83	(13)
300	5	
400	25	
500	100	
600	336	

H-Ni

400	0.95	(1)
500	3.80	
600	8.86	
700	23.8	
750	31.6	

H-Pd

200	400	(7)
300	1820	
400	3160	
500	4450	
600	5750	

H-Pt

600	0.77	(12)
700	2.0	
800	4.3	
900	10.0	
1000	17.1	
1100	30.2	

H-Zn

θ	K	Lit.
300	0.4	(1)

He-Pt-Ir

Scarcely appreciable up to θ = 1420° (3)

N-Mild Steel

600	0.5	(13)
700	1.6	
800	5.0	
1000	11.6	

O-Ag

400	0.0032	(6)
450	0.0097	
500	0.021	
550	0.057	
600	0.146	

CO-Mild Steel

400	0.5	(13)
500	1.6	
600	5	
700	23	
800	67	
835	133	

850, K falls suddenly almost to zero.

VULCANIZED RUBBER†

A

25	0.088	(4)

H

θ	K	Lit.
0	0.12	(4)
20	0.30	
25	0.34	
40	0.57	
60	1.02	
80	1.68	
100	2.60	

He

0	0.075	(4)
20	0.21	
25	0.22	
40	0.36	
60	0.66	
80	1.08	
100	1.56	

N

25	0.054	(4)

O

25	0.150	(4)

CO_2

0	0.30	(4)
20	0.84	
25	0.98	
40	1.77	
60	3.88	
80	4.00	
100	5.30	

C_2H_5Cl

25	68	(4)

CH_3Cl

25	6.3	(4)

H_2O

25	16.0	(4)
25	35.0(l)	

NH_3

25	2.7	(4)

Air

25	0.075	(4)

GLASS

A-SiO_2‡

900	1.4	(5)

H-SiO_2‡

300	1.9	(5)
	7	(16)
400	3.5	(15)
	17	(8)

H-SiO_2‡.—(*Cont'd*)

θ	K	Lit.
500	6.2	(15)
	28	(8)
600	11	(15)
	50	(8)
700	17	(15)
	80	(8)
800	35	(15)
	100	(5)
900	55	(15)
	140	(5)
1000	128	(16)

He-SiO_2‡

200	14	(15)
300	35	(15)
400	70	(15)
500	157	(15)
600	350	(15)
1200	210	(14)

N-SiO_2‡

600	0.11	(5)
700	0.50	
800	1.68	
900	4.8	

Pyrex

H

K inappreciable at θ = 600°

He

610	14	(15)

Jena

H

K inappreciable at θ = 800°

Thuringian

He

100	0.000081	(10)
200	0.009	
300	0.064	
400	0.340	
500	1.000	

Cu§

Gas	K/K_H	Lit.
θ = 700°C		
H	1	(9)
CO	0.017	
CO_2	0.0006	
H_2O	0.065	

PURE PARA RUBBER‖

$\theta = 15°C$

Gas	K/K_H	Lit.	Gas	K/K_H	Lit.
A	0.19	(2)	CO	0.16	(2)
H	1.00		CO_2	2.5	
He	0.3		C_2H_5OH	250	
N	0.11		H_2O	16.0	
O	0.35		Air	0.17	

* Values for Cu and relative to H are given near end of table.
† Relative values for pure Para rubber are at end of table.
‡ Quartz glass. For H, extreme values are given.
§ *v. also* beginning of table. ‖ *cf.* vulcanized rubber.

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DIFFUSION IN SOLIDS

C. H. DESCH

Δ = Coefficient of diffusion. For definition, *see* Vol. I, p. 36

Diffusing system	t, °C	Δ, cm²/day	Lit.
Au in Pb	197	76×10^{-4}	(15); agrees well with (10)
	150	43×10^{-4}	
	100	$2+ \times 10^{-4}$	
Au in Ag	935	11×10^{-5}	(16)
	885	48×10^{-6}	(16)
	870	37×10^{-6}	(5)
	835	21×10^{-6}	(16)
Au (from solid solution) in Ag	916	52×10^{-5}	(2)
	847	22×10^{-5}	(2)
	767	11×10^{-5}	(2)
Cu in Ni	1000	115×10^{-7}	(8)
Ni in Cu	1000	55×10^{-8}	(8)
Th in W	2027	95×10^{-6}	(4)
Po in Au	470	1×10^{-9}	(17)
Ra-B + C in Ag	470	4×10^{-7}	(17)
Ra-B + C in Au	470	8×10^{-7}	(17)
Ra-B + C in Pt	470	3×10^{-7}	(17)
Zn in Cu (α)	400	2×10^{-8}	(8)
Th-B in Pb	324	14×10^{-5}	(7)
	320	47×10^{-6}	(7)
	310	57×10^{-7}	(7)
	300	25×10^{-7}	(7)
	280	15×10^{-7}	(7)
	260	6×10^{-7}	(7)
Po in Pb	310	13×10^{-6}	(7)
Th-B in Tl	285	2×10^{-5}	(7)
C in γ-Fe	930	29×10^{-3}	(14)
	930	17×10^{-3}	(11)

DIFFUSION OF IONS IN CRYSTALLINE SOLIDS

Na in permutite	20	112×10^{-5}	(12)
Ag in permutite	20	164×10^{-5}	(12)
Na in natrolite	20	13×10^{-6}	(12)
Ag in Cu_2S		1.0	(2)

DIFFUSION OF OXYGEN INTO SILVER AT 400–630°

$$x = \frac{43\,054}{h} p^{½} T^{½} e^{\frac{-43\,232}{4t}},$$

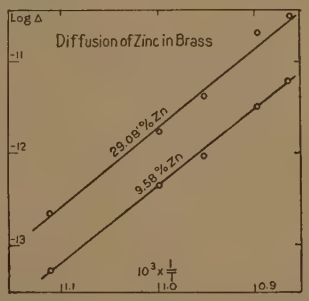
where x = velocity of diffusion in cm³/m² per hr; p = pressure of oxygen in mm, h = thickness of silver foil in mm, and T = abs. temp. (9).

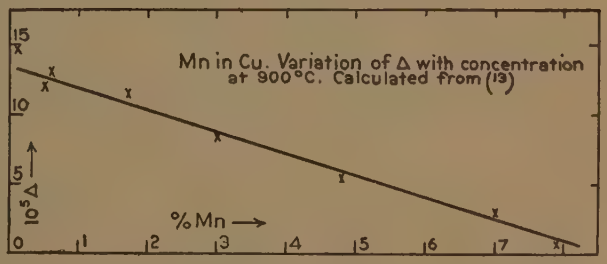
DIFFUSION OF ZINC IN BRASS

The values of the diffusion of zinc in α-brass are shown in Fig. 1. The results may be expressed by the equation $\Delta = Ae^{-Q/RT}$ (18).

Discussion

The differences between the values for the diffusion of gold in silver obtained by Weiss and by Fraenkel (5, 16) on the one hand and by Braune (2) on the other may be attributed to the use of an alloy by the latter. It seems certain that the coefficient of diffusion in solids is not a constant, but falls off as the concentration of the solid solution increases. This is shown by Fig. 2. Probably a similar difference accounts for the discrepancy between the results of Tammann and those of Runge for the diffusion of carbon in γ-iron.





It is possible that diffusion does not occur in a single crystal of a metal unless the entering atoms are very different from those of the crystal. Hevesy and Obrutsheva (7) found no diffusion of thorium B in a single crystal of lead, the coefficient at a temperature only just below the melting point being certainly less than 10^{-8} cm²/day. On the other hand, polonium diffused into single crystals of lead and into lead foil at about the same rate. Geiss and van Liempt (6) found no diffusion of either carbon or iron into single crystal wires of tungsten, although in the powdered condition diffusion occurred readily. Andrews and Dushman (1) determined the diffusion of carbon into tungsten wires, but did not calculate a coefficient of diffusion. They give a "coefficient

of penetration," which is not identical with it, and similar empirical coefficients are found by Weiss [16] and by Bruni and Meneghini [3] for the systems Cu-Ni, Cu-Au, and Ag-Au.

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MECHANICAL EQUIVALENT OF HEAT

T. H. Laby and E. O. Hercus

Data based upon electrical measurements have been recalculated to the basis of International ohm = $1.000\,52 \times 10^9$ cgsm, International ampere (defined by silver voltameter) = $0.999\,97 \times 10^{-1}$ cgsm, International volt (defined by ampere and ohm) = $1.000\,49 \times 10^8$ cgsm, Weston normal cell at 20°C = 1.0188×10^8 cgsm. Reduction to the 20°C, or the mean, calorie is by Callendar's formula [3].

$$c = 0.98536 + \frac{0.504}{t+20} + 0.0084\,\frac{t}{100} + 0.009\left(\frac{t}{100}\right)^2$$

c = specific heat in gram-calories, t = °C.

Value of 1 G Calorie

Unit = 10^7 erg, w = weight assigned

Observer	w	20°C calorie	Mean calorie	Lit.
Rowland; Day*	6	4.182†		(4, 9)
Reynolds and Moorby*	2		4.1836‡	(7)
Rispail*	1	4.180¶		(8)
Griffiths‖	2	4.1904**		(5)
Schuster and Gannon‖	1	4.1898††		(10)
Callendar and Barnes‖	3	4.1795‡‡		(1)
Jaeger and Steinwehr‖	3	4.1821		(6)
Bousfield and Bousfield‖	1	4.1767		(2)
Henning-Sutton§§	1		4.1865‖‖	(11, 12)
Henning-Joly§§	1		4.1877	(11, 12)
Weighted mean		4.1818	4.1853	
Osborne, Stimson and Fiock‖			4.188¶¶	(13)
Laby and Hercus*		4.1809		(14)

* Direct method.
† As given by Day.
‡ Corrected from 1 to 100° to 0 to 100°.
‖ Electrical method.
¶ Reduced from 15 to 20° by Callendar's formula.
** Corrected to 20°, for displaced air [10], and to Clark cell 15°C = 1.4336×10^8 cgsm.
†† Assumed presence of filter paper increased deposit by 2 in 10 000.
‡‡ Calculated on basis of King's determination of their cells = 1.4334 International volt = 1.43410×10^8 cgsm, and Barnes value: 1.4335.
§§ Latent heat of steam.
‖‖ Used weights assigned by Henning.
¶¶ ±0.02 % according to the authors.

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THE HEAT CAPACITY OF GASES AND VAPORS

A. LEDUC

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CONVERSION FACTORS

To convert joule g^{-1} deg^{-1} C into g-cal_{15} g^{-1} deg^{-1} C or into BTU_{60} $lb.^{-1}$ deg^{-1} F, multiply by 0.23895.

For conversion into other units, *v.* Vol. I, p. 24.

FACTEURS DE CONVERSION

Pour convertir les C exprimées en joules g^{-1} deg^{-1} C en cal_{15}-g g^{-1} deg^{-1} C, ou en BTU_{60} $lb.^{-1}$ deg^{-1} F multiplier par 0,23895.

Pour convertir en d'autres unités, *v.* Vol. I, p. 24.

UMRECHNUNGSFAKTOREN

Um Joule g^{-1} $Grad^{-1}$ C in Gramm-cal_{15} g^{-1} $Grad^{-1}$ C umzurechnen multipliziere man mit 0,23895.

Für Umrechnungen zu anderen Einheiten, *siehe* Bd. I, S. 24.

FATTORI DI CONVERSIONE

Per convertire i joule g^{-1} $gradi^{-1}$ C in g-cal_{15} g^{-1} $gradi^{-1}$ C oppure in BTU_{60} $lb.^{-1}$ $gradi^{-1}$ F bisogna moltiplicare per 0,23895.

Per le conversioni in altre unità, *vedi* Vol. I, p. 24.

ABBREVIATIONS, SYMBOLS AND UNITS

c_p (resp. c_v) Heat capacity per gram at constant pressure (resp. at constant volume).

C_p (resp. C_v) Heat capacity per gram-mole at constant pressure (resp. at constant volume).

c_m (resp. C_m) Mean capacity.

δ $c_p - c_v$.

γ $c_p/c_v = C_p/C_v$.

Units: Throughout this section, unless otherwise indicated, the unit of heat energy is the joule, the unit of mass, the gram (or gram-mole) and the unit of temperature, the degree centigrade.

ABRÉVIATIONS, SYMBOLES ET UNITÉS

c_p (resp. c_v) Capacité calorifique par gramme sous pression constante et à volume constant respectivement.

C_p (resp. C_v) Capacité calorifique par molécule-gramme sous pression constante et à volume constant respectivement.

c_m (resp. C_m) Capacité moyenne.

δ $c_p - c_v$.

γ $c_p/c_v = C_p/C_v$.

Unités: Dans cette section, à moins d'indication contraire, l'unité d'énergie calorifique est le joule, l'unité de masse le gramme (ou la molécule-gramme), et la température est exprimée en degrés centigrades.

ABKÜRZUNGEN, ZEICHEN UND EINHEITEN

c_p (bezw. c_v) Wärmeinhalt pro Gramm bei konstantem Druck (bezw. bei konstantem Volumen).

C_p (bezw. C_v) Wärmeinhalt pro Gramm-Mol bei konstantem Druck (bezw. bei konstantem Volumen).

c_m (bezw. C_m) Mittlere Wärmeinhalt.

δ $c_p - c_v$.

γ $c_p/c_v = C_p/C_v$.

Einheiten: Wenn nichts besonderes angegeben, so ist durchgehend in diesem Abschnitt die Einheit der Wärmeenergie in Joule, die Einheit der Masse in Gramm (oder Gramm-Mol) und die Temperatureinheit in Centigraden, angegeben.

ABBREVIAZIONI, SIMBOLI E UNITÀ

c_p (oppure c_v) Capacità calorifica per grammi sotto pressione costante (oppure a volume costante).

C_p (oppure C_v) Capacità calorifica per grammimolecola sotto pressione costante (oppure a volume costante).

c_m (oppure C_m) Calore specifico medio.

δ $c_p - c_v$.

γ $c_p/c_v = C_p/C_v$.

Unità: In questo capitolo, a meno che non sia altrimenti indicato, l'unità di energia calorifica è il joule, l'unità di massa, il grammo (o la grammimolecola) e l'unità di temperatura, il grado centigrado.

INTRODUCTION

Each of the four quantities, c_p, c_v, δ and γ, is capable of independent experimental determination and it is sufficient to know any two in order to calculate the other two, but knowledge of a third serves as a valuable check.

The most accurate determinations of γ are based upon the measurement of the velocity of sound, V, and the relations:

$$V = \sqrt{\frac{E}{d}} = \frac{1}{d}\sqrt{-\gamma\frac{\partial p}{\partial v}} \qquad \text{(Laplace)}$$

and

$$V_{obs.} = V\left(1 - \frac{k}{2r\sqrt{\pi N}}\right) \qquad \text{(Kirchhoff)}$$

where d is the density of the gas; v, the specific volume; $V_{obs.}$, the velocity as measured in a tube of radius $r \geq 2.5$ cm; N, the frequency; and k, a correction factor ($= ca.$ 0.65) which depends in an unknown manner upon the properties of the gas (*e.g.*, upon the viscosity) and upon the nature of the tube.

The quantity δ is computed from the thermodynamic relation

$$\delta = T\left(\frac{\partial p}{\partial T}\right)_v\left(\frac{\partial v}{\partial T}\right)_p$$

In preparing the tables in this section the values of $\partial p/\partial T$, $\partial v/\partial T$ and $\partial p/\partial v$ required in the above equations were obtained by one (or more) of the following methods, preference being given in the order shown: (1) Accurate values based upon direct measurement; (2) values deduced from an equation of state known to correctly reproduce the observed p, v, T for the gas; (3) values deduced from a general equation of state obtained by the author. Method (3) was used in the majority of cases. For details, *v.* (29, 35).

Owing to the fact that the available data give, in many instances, opportunities for frequent cross-checks, it is not always possible to indicate, except partially, the source of all of the experimental data upon which the values given below are based. For a critique of the experimental data in this field and a discussion of the various corrections required, *v.* (35.5).

In all of the tables given below the quantity recorded is the total heat capacity, that is, it includes, for example, any "heat of dissociation" which may accompany the rise in temperature. Consequently a value given cannot be taken as the "true" specific heat of a molecular species unless it is known that a dissociation equilibrium is not involved.

THE COMMON GASES AT 15°C

p = 1 atm.

Gas	$C_p - C_v$	γ	C_p	Gas	$C_p - C_v$	γ	C_p
A	8.345	1.668	20.93	NO	8.353	1.400	29.25
Cl_2	8.934	1.355	34.11	NH_3	8.822	1.310	37.29
H_2	8.316	1.410	28.58	CO	8.349	1.404	29.04
N_2	8.349	1.404	29.04	CO_2	8.542	1.304	36.62
O_2	8.349	1.401	29.17	CN	9.081	1.256	44.57
HCl	8.609	1.41	29.59	CH_4	8.387	1.31	35.45
SO_2	9.136	1.29	40.64	C_2H_2	8.609	1.26	41.72
H_2S	8.755	1.32	36.12	C_2H_4	8.609	1.255	42.14
N_2O	8.579	1.303	36.91	C_2H_6	8.734	1.22	48.55

THE COMMON GASES AT LOW TEMPERATURES

See also p. 84

p = 1 atm. (53)

Gas	t, °C	γ	C_p	C_v	Sign of $\partial C_p/\partial t$
A	−180	1.76?	22.2	12.6	−
H_2	−76	1.453	26.6	18.3	+
	−181	1.597	22.3	14.0	+
He	−180	1.660	20.9	12.6	+
N_2	−181	1.47	30.0	20.4	−
O_2	−76	1.415	28.7	20.3	−
	−181	1.45	30.6	21.1	−
H_2S*	−45	1.30	39.8	30.7	−
	−57	1.29	41.7	32.4	−
N_2O	−30	1.31	36.8	28.1	+
	−70	1.34	35.0	26.1	+
NO*	−45	1.39	30.0	21.6	−
	−80	1.38	30.7	22.2	−
CO	−180	1.41	30.3	20.6	−
CO_2	−75	1.37	33.8	24.7	+
CH_4	−80	1.34	33.8	25.2	+
CH_4 (37.9)	−74	1.35	33.4	24.8	+
	−115	1.41	30.2	21.4	+
C_2H_2	−71	1.31	38.2	29.1	+
C_2H_4	−91	1.35	36.2	26.8	+
C_2H_6	−82	1.28	43.7	34.1	+

* Values doubtful.

VALUES OF $\gamma = c_p/c_v$

A-Table, Elementary Substances and Atmospheric Air

Formula	$p_{atm.}$	t, °C	γ	Lit.
A	1	0–100	1.67	(43)
Br	0.3–1.5	20–350	1.32	(59)
Cl	1	16	1.355	(23, 45)
	0.5	16	1.34	(23)
H_2 (*v.* p. 82)	1	17	1.407	(2.5)
	1	− 21	1.420	
	1	− 78	1.443	
	1	−118	1.480	
	1	−185	1.605	
Hg	0.5–1	360	1.67	(27)
I	1	185	1.30	(58)
K	1	850	1.77	(65)
	1	680–1000	1.69	(51)
Kr	1	19	1.68	(49)
Na	1	750–920	1.68	(51)
Ne	1	19	1.64	(49)

A-Table.—(*Continued*)

Formula	$p_{atm.}$	t, °C	γ	Lit.
P	1	300	1.17	(56)
Xe	1	19	1.66	(49)
Air (*v.* p. 81)	100	− 79	2.20	(26)
	200	− 79	3.33	(26)
	3	20	1.41	(54)
	1	925	1.36	(22, 58)
	1	17	1.403	(2.5)
	1	− 78	1.408	
	1	−118	1.415	

B-Table, Chemical Compounds

Formula	$p_{atm.}$	t, °C	γ	Lit.
HCl	1	100	1.40	(59)
HBr	0.3–1.5	20	1.42	(59)
HI	1	20–100	1.40	(59)
ICl	1	100	1.31	(59)
SO_2	0.5	20	1.27	(54)
	2.5	20	1.35	(4, 60)
H_2S	1	18	1.30	(60)
	0.5	18	1.32	(60)
N_2O	1	0	1.32	(68)
	1	100	1.28	(68)
NH_3	1	15	1.31	(54)
	3.5	15	1.41	(54)
CS_2	satd. vap.	99.7	1.63	(28, 58)
$SiCl_4$	0.15	14	1.13	(4)

C-Table, C-Compounds

Formula	Name	$p_{atm.}$	t, °C	γ	Lit.
CCl_4	Carbon tetrachloride	0.1	20	1.13	(4, 62)
$CHCl_3$	Chloroform	0.15	20	1.15	(4)
		1	100	1.15	(58)
HCN	Hydrogen cyanide	1	65	1.31	(63)
		1	140	1.28	(63)
		1	210	1.24	(63)
CH_2Cl_2	Dichloromethane	0.2	18	1.22	(4)
CH_3Br	Methyl bromide	0.3–0.6	18	1.27	(4)
CH_3Cl	Methyl chloride	0.8	16	1.28	(4)
CH_3I	Methyl iodide	0.3	20	1.286	(4)
CH_4O	Methyl alcohol (C_p = 52.3)	1	77	1.203	(11)
C_2H_3Br	Bromoethylene	0.6	15	1.20	(4)
C_2H_4	Ethylene	1	100	1.18	(68)
$C_2H_4Cl_2$	1, 2-Dichloroethane	0.06	19	1.137	(4)
		0.2	23	1.134	(4)
C_2H_4O	Acetaldehyde	1	30	1.14	(68)
$C_2H_4O_2$	Acetic acid	1	136	1.15	(58)
C_2H_5Br	Ethyl bromide	0.3	14	1.19	(4)
C_2H_5Cl	Ethyl chloride	0.3–0.5	16	1.19	(4)
C_2H_6	Ethane	1	50	1.21	(10)
		1	100	1.19	(10)
C_2H_6O	Ethyl alcohol (C_p = 78.3)	1	90	1.13	(11, 42)
C_2H_6O	Methyl ether	1	6–30	1.11	(39)
C_3H_5Br	Allyl bromide	0.1	15	1.145	(4)
C_3H_5Cl	Allyl chloride	0.2	14	1.137	(4)
$C_3H_6O_2$	Methyl acetate	*ca.*1	*ca.*15	1.14	(4)
C_3H_7Br	Isopropyl bromide	0.23	12	1.13	(4)
C_3H_7Cl	*n*- and *iso*-Propyl chloride	0.1	21	1.13	(4)
C_3H_8	Propane	0.5	16	1.13	(4)
$C_3H_8O_2$	Methylal	1	13	1.06	(39)
		1	40	1.09	(39)
C_4H_{10}	Isobutane	*ca.*1	*ca.*15	1.11	(6)

C-TABLE.—(*Continued*)

Formula	Name	$p_{atm.}$	t, °C	γ	Lit.
$C_4H_{10}O$	Ethyl ether (C_p = 116.3)	1	35	1.08	(30)
		1	80	1.086	(11, 42)
C_6H_{12}	Cyclohexane	1	80	1.08	(7)

			C_p	t	γ	Lit.
C_5H_{12}	*n*-Pentane	1 atm.	123.5	86	1.086	(11, 42)
C_6H_6	Benzene	1 atm.	106.3	90	1.10	(7, 11)
C_6H_{14}	*n*-Hexane	1 atm.	131.4	80	1.08	(11)

VALUES OF c_p AT t AND OF c_p, MEAN, BETWEEN t_1 AND t_2

ELEMENTS AND INORGANIC COMPOUNDS

Formula	$p_{atm.}$	t, °C	c_p	Lit.
Br	1	83–228	0.230	(50)
	1	19–388	0.230	(59)
I	1	206–377	0.141	(59)
HCl	1	10–190	0.774	(50)
HBr	1	11–100	0.343	(59)
ICl	1	100–203	0.213	(59)
SO_2	1	10–190	0.561	(50)
H_2S	1	10–190	1.017	(61)
SO_2Cl_2	1	19–98	0.477	(61.5)
N_2O	1	25–100	0.887	(50)
	1	25–200	0.937	(50, 66)
	11	30–94	1.017	(37)
	31	30–94	1.172	(37)
NO	1	10–180	0.971	(50)
NO_2; *v. also* (37.5)	1	27–67	6.78	(1.5)
	1	27–100	6.11	(1.5)
	1	27–150	4.666	(1.5)
	1	27–200	3.56	(1.5)
	1	27–300	2.68	(1.5)
PCl_3	1	110–250	0.565	(50)
$AsCl_3$	1	160–270	0.469	(50)
CCl_4	1	0	0.586	(38)
	1	30	0.552	(38)
	1	70	0.481	(38)
CS_2	1	80–190	0.657	(50)
	0.3	17	0.657	(60)
$SiCl_4$	1	90–230	0.552	(50)
$TiCl_4$	1	160–270	0.540	(50)
$SnCl_4$	1	149–273	0.393	(50)

ORGANIC COMPOUNDS

Formula	Name	$p_{atm.}$	t, °C	c_p	Lit.
$CHCl_3$	Chloroform	1	27–118	0.607	(66)
		1	120–230	0.657	(50)
CH_4	Methane	1	10–200	2.482	(9, 50)
		11	30–94	2.620	(37)
		31	30–94	2.909	(37)
CH_4O	Methyl alcohol	1	100–223	1.917	(50)
C_2H_4	Ethylene	1	15–100	1.67	(50, 66)
		1	25–200	1.80	(66)
		11	30–94	1.76	(37)
		31	30–94	1.88	(37)
$C_2H_4Cl_2$	1, 1-Dichloroethane	1	110–220	0.963	(50)
$C_2H_4Cl_2$	Ethylene chloride	1	111–221	0.96	(50)
$C_2H_4O_2$	Acetic acid	1	118–140	6.28	(1.5)
		1	140–180	5.31	(1.5)
		1	180–220	3.98	(1.5)
		1	220–260	2.67	(1.5)
C_2H_5Br	Ethyl bromide	1	28–116	0.674	(66)
		1	80–200	0.795	(50)

ORGANIC COMPOUNDS.—(*Continued*)

Formula	Name	$p_{atm.}$	t, °C	c_p	Lit.
C_2H_5Cl	Ethyl chloride	1	10–170	1.151	(50)
		1	15–100	1.021	(20)
C_2H_6O	Ethyl alcohol	1	100–223	1.90	(50)
C_3H_5N	Ethyl cyanide	1	114–223	1.783	(50)
C_3H_6O	Acetone	1	26–110	1.452	(50)
		1	130–230	1.724	(50)
$C_4H_8O_2$	Ethyl acetate	1	110–220	1.678	(50)
		1	35–189	1.553	(66)
		1	35–113	1.410	(66)
$C_4H_{10}O$	Ethyl ether	1	35	1.862	(30)
		1	27–189	1.933	(66)
		1	69–224	2.01	(50, 55)
		1	200–300	2.231	(55)
		0.28	16	1.92	(60)
		0.28	350	2.51	(60)
$C_4H_{10}S$	Diethyl sulfide	1	120–223	1.67	(50)
C_5H_{10}	Amylene		*ca.* 210	2.64	(14)
C_5H_{12}	Isopentane	1	58	1.88	(64)
		1	100	1.97	(8)
C_6H_6	Benzene	1	80	1.09	(30)
		1	34–115	1.26	(66)
		1	35–180	1.39	(66)
		1	100	1.39	(7)
		1	120–220	1.55	(50)
C_6H_{12}	Cyclohexane	1	100	1.73	(7)
$C_{10}H_{16}$	Terebenthene	1	180–250	2.12	(50)

SPECIAL TABLES

Atmospheric Air

EFFECT OF TEMPERATURE

p = 1 atm. (2, 9, 16, 46, 48)

t, °C	$c_p - c_v$	γ	c_p	c_m, 0 to t°
0	0.2883	1.403	1.004	1.004
100	0.2882	1.401	1.006	1.005
200	0.2875	1.398	1.010	1.009
400	0.2871	1.393	1.017	1.013
600	0.2871	1.385	1.034	1.017
800	0.2871	1.376	1.055	1.025
1000	0.2871	1.365	1.076	1.034
1200	0.2871	1.353	1.101	1.042
1400	0.2871	1.341	1.130	1.050
1600	0.2871	1.329	1.160	1.063
1800	0.2871	1.316	1.193	1.076
2000	0.2871	1.303	1.234	1.088

EFFECT OF PRESSURE

Values of c_p above 0° (52)

$p_{atm.}$	0°	50°	100°	150°	200°	280°
20	1.042	1.038	1.034	1.034	1.030	1.034
60	1.113	1.088	1.071	1.059	1.050	1.042
100	1.172	1.138	1.088	1.088	1.076	1.055
140		1.180	1.138	1.113	1.092	1.063
180		1.214	1.168	1.134	1.109	1.076
220		1.239	1.189	1.151	1.122	1.084

Values of c_p below 0° (67)

$p_{atm.}$	−50°	−100°	−120°	−140°
10	1.021	1.080	1.138	1.707
20	1.055	1.184	1.348	2.678
40	1.147	1.400	2.005	10.91
70	1.306	1.925	3.252	

	−78°	−185°	Lit.
1	1.017	1.055	(53)

Atmospheric Air.—(*Continued*)

VALUES OF γ

$p_{atm.}$	0°		−79.4°	
	(26)	(67)	(26)	(67)
25	1.47	1.47	1.57	1.58
50	1.53	1.53	1.77	1.79
75	1.59	1.58	2.00	2.06
100	1.65	1.64	2.20	2.30
125	1.69		2.40	
150	1.74		2.47 max.	
175	1.78		2.41	
200	1.83		2.33	

VALUES c_v, MEAN, 15–100° (21)

d, g/cm³	0.01	0.03	p = 1 atm.
c_v	0.719	0.721	0.717

H_2, Hydrogen; *cf.* (69)

t, °C (5, 48, 57)	C_p	γ	C_m, 0 − t°	t, °K (12)	C_v
0	28.58	1.410	28.58	35	12.47
100	28.92	1.404	28.75	50	12.60
200	29.21	1.398	28.92	65	12.72
400	29.80	1.387	29.21	80	13.14
600	30.38	1.377	29.50	90	13.64
800	30.97	1.367	29.80	100	14.31
1000	31.55	1.358	30.09	110	15.15
1200	32.14	1.349	30.38	196.5	18.37
1400	32.73	1.341	30.68	273.1	20.26
1600	33.31	1.333	30.97		
1800	33.90	1.325	31.26		
2000	34.48	1.318	31.55		

O_2, N_2 and CO

For best values at 0°, *v.* p. 81; *see also* Fig. 2. The following values are from Partington and Shilling (47):

t°, C	$C_p - C_v$	γ	C_p	C_m, 0 to t°
0	8.362	1.402	29.17	29.17
100	8.332	1.399	29.21	29.19
200	8.324	1.396	29.29	29.23
400	8.324	1.391	29.63	29.34
600	8.320	1.383	30.01	29.50
800	8.320	1.375	30.51	29.67
1000	8.316	1.365	31.14	29.92
1200	8.316	1.353	31.85	30.17
1400	8.316	1.342	32.64	30.47
1600	8.316	1.329	33.56	30.80
1800	8.316	1.316	34.61	31.18
2000	8.316	1.303	35.74	31.55

For N_2 { $C_p = 6.815 + 3.17 \times 10^{-4}t + 5.3 \times 10^{-8}t^2$ g-cal$_{15}$/mole.
$C_v = 4.82 + 3.3 \times 10^{-4}t + 4.7 \times 10^{-8}t^2$ g-cal$_{15}$/mole.

For O_2 { $C_p = 6.98 + 1.88 \times 10^{-4}t + 6.7 \times 10^{-8}t^2$ g-cal$_{15}$/mole.
$C_v = 4.98 + 2.1 \times 10^{-4}t + 5.5 \times 10^{-8}t^2$ g-cal$_{15}$/mole.

H_2O

VARIATION OF c_p WITH TEMPERATURE AND PRESSURE (17, 25)

t, °C	1 atm.	2 atm.	4 atm.	6 atm.	10 atm.	14 atm.	20 atm.
100	2.017						
120	1.996	2.093					
140	1.984	2.046					
160	1.975	2.021	2.155	2.356			
180	1.971	2.005	2.101	2.226	2.645		
200	1.971	1.996	2.067	2.151	2.381	2.808	
250	1.980	1.996	2.034	2.072	2.155	2.264	2.461
300	1.996	2.009	2.034	2.059	2.109	2.159	2.247

H_2O.—(*Continued*)

VARIATION OF c_p WITH TEMPERATURE AND PRESSURE.—(*Cont'd*)

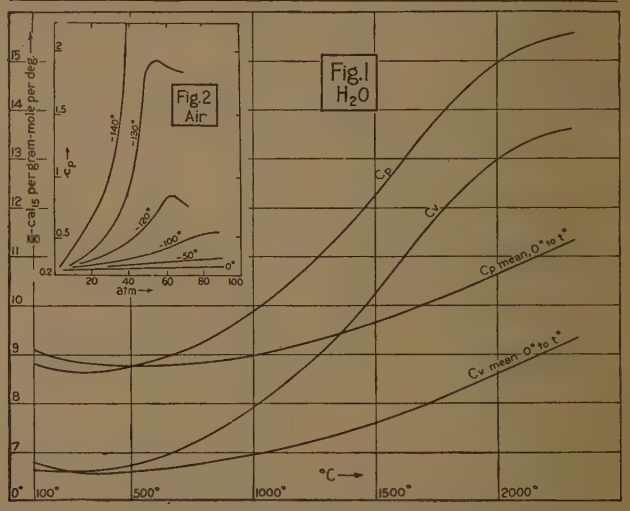
t, °C	1 atm.	2 atm.	4 atm.	6 atm.	10 atm.	14 atm.	20 atm.
350	2.021	2.025	2.051	2.067	2.109	2.147	2.214
400	2.051	2.059	2.076	2.093	2.122	2.155	2.205
450	2.084	2.093	2.113	2.118	2.139	2.164	2.201
500	2.122	2.126	2.134	2.143	2.159	2.176	2.201
550	2.156	2.159	2.164	2.168	2.180	2.189	2.210

VARIATION OF c_p WITH TEMPERATURE FOR p = 1 ATM. (15)

t, °C	200	400	600	800	1000	1200	1400
c_p	1.946 extrap.	1.980	2.055	2.172	2.335	2.544	2.796

"BEST" VALUES FOR p = 1 ATM. (47)

t, °C	$C_p - C_v$	γ	C_v	t, °C	$C_p - C_v$	γ	C_v
100	8.927	1.324	27.54	1000	8.328	1.252	33.06
200	8.550	1.310	27.58	1200	8.324	1.229	36.41
300	8.424	1.304	27.66	1400	8.320	1.206	40.47
400	8.378	1.301	27.83	1600	8.320	1.182	45.32
500	8.357	1.296	28.21	1800	8.320	1.163	42.56
600	8.345	1.290	28.80	2000	8.320	1.155	54.20
700	8.337	1.282	29.55	2200	8.320	1.148	56.29
800	8.332	1.273	30.55	2300	8.320	1.146	56.79
900	8.328	1.263	31.68				



MEAN C_p BETWEEN 100 AND t° (40)

t, °C	1000	1250	1500	1750	2000	2250	2500	3000
C_p, 100–t°	28.96	30.13	31.39	33.06	35.24	37.62	40.00	45.41

c_p FOR SLIGHTLY UNDER-SATURATED VAPOR* (17)

t, °C	99.1	119.6	142.9	169.6	187.1	200.5	211.4
p, kg/cm²	1	2	4	8	12	16	20
c_p	2.017	2.088	2.231	2.511	2.817	3.135	3.490

* These values are not in agreement with those calculated thermodynamically from the temperature coefficient of the latent heat.

"BEST" VALUES FOR THE SATURATED VAPOR

t, °C	c_p	c_v	γ
100	1.816	1.318	1.373*
120	1.871	1.356	1.378
140	1.971	1.422	1.380

* This is consistent with Neyreneuf's value of the velocity of sound (42).

"BEST" VALUES FOR THE SUPERHEATED VAPOR

p, atm.	t, °C	100	120	140	150	160
1	c_p	1.816	1.833	1.875	1.93	2.005
	γ		1.365	1.346	1.333	1.314

H_2O.—(*Continued*)

"BEST" VALUES FOR THE SUPERHEATED VAPOR.—(*Cont'd*)

p, atm.	t, °C	100	120	140	150	160
2	c_p		1.871	1.913	1.959	2.026
	γ		1.37*	1.36	1.344	1.326
3	c_p			1.959		
	γ			1.37	1.356	1.34
4	c_p				2.026	2.076
	γ		*At 130°		1.37	1.35

NH_3

VARIATION OF c_p WITH TEMPERATURE AND PRESSURE (44)

t, °C \ $p_{atm.}$	0	1	2	4	8	12	16	20
Satd.		2.340	2.483	2.701	3.030	3.300	3.561	3.843
−30	2.020	2.306						
−10	2.043	2.195	2.386					
0	2.057	2.173	2.314	2.657				
+20	2.085	2.159	2.244	2.446	2.988			
40	2.116	2.167	2.252	2.350	2.665	3.073		
60	2.149	2.186	2.226	2.313	2.515	2.759	3.058	3.448
80	2.184	2.212	2.242	2.305	2.445	2.605	2.789	3.008
100	2.220	2.214	2.265	2.312	2.415	2.528	2.652	2.792
120	2.256	2.274	2.293	2.330	2.409	2.492	2.582	2.679
150	2.294	2.327	2.340	2.368	2.422	2.481	2.540	2.603

VALUES OF c_p AT HIGH TEMPERATURES

Mean of (13 and 41) ±10%

t	309°	422°	523°
C_p	41.4	43.9	47.08
c_p	2.43	2.59	2.76

Nernst (41) gives $C_p = 8.62 + 0.002t + 7.2 \times 10^{-9}t^2$, g-cal$_{15}$/mole. Range 0 to 680°.

For very high temperatures Budde (3) gives the equation $C_p = 11.8 + 0.024 \times (t - 1400)$, g-cal$_{15}$/mole. This gives 11.8 at 1400° and 21.4 at 2200°.

CO, *v.* p. 86

CO_2

EFFECT OF TEMPERATURE AT p = 1 ATM. (2, 11, 15, 48)

$C_p = 6.63 + 5.54 \times 10^{-3}t - 2.47 \times 10^{-6}t^2 + 4.7 \times 10^{-10}t^3$, g-cal$_{15}$/mole (53)

t, °C	$C_p - C_v$	γ	C_p	C_m, 0–t°
0	8.600	1.310	36.33	36.33
100	8.429	1.281	38.38	37.37
200	8.374	1.263	40.18	38.25
300	8.349	1.247	42.18	39.09
400	8.337	1.235	43.82	39.92
500	8.328	1.225	45.24	40.76
600	8.324	1.217	46.60	41.43
700	8.324	1.210	47.86	42.27
800	8.320	1.204	49.01	42.98
900	8.320	1.200	50.01	43.69
1000	8.320	1.195	50.89	44.24
1100	8.320	1.192	51.68	44.78
1200	8.314	1.189	52.40	45.24
1300	8.314	1.186	53.02	45.73
1400	8.314	1.184	53.61	46.24
1500	8.314	1.181	54.20	46.75
1600	8.314	1.179	54.74	47.21
1700	8.314	1.177	55.28	47.75
1800	8.314	1.175	55.83	48.25
1900	8.314	1.173	56.33	48.76
2000	8.314	1.171	56.92	49.26

Between −75 and +20°, $C_p = 8.71 + 66 \times 10^{-4}t - 22 \times 10^{-7}t^2$ g-cal/mole (15).

CO_2.—(*Continued*)

VARIATION OF c_p WITH PRESSURE, $\frac{\partial c}{\partial p} > 0$, $\frac{\partial c}{\partial T} < 0$ (37.2)

For data near the critical point, *v.* (1)

$p_{atm.}$	13.2°	38°	67.6°	98.1°	114.9°
24.25		1.205	1.030		
54.1	3.06	1.364	1.151		
61.7	3.72	1.833	1.352	1.327	1.310
68.2	4.70	2.369			
75.8	6.16	3.059	2.026	1.93	1.611
85.4	8.83	4.164		2.498	2.226
86.9			2.691		

$p_{atm.}$ (19)	−10°	0°	+10°	20°	30°
20.5	1.201	1.159	1.117	1.071	1.030
27.3		1.381	1.289	1.193	1.058

VARIATION OF c_v WITH t AND d (21)

	d = 0.124 g/cm³			d = 0.18 g/cm³	
t, °C	10	50	100	50	100
c_v	0.933	0.824	0.795	0.866	0.862
d, g/cm³		0.0387	0.077	0.118	0.144
c_m, 12–100°		0.7173	0.7700	0.8119	0.8457

$c_v = 0.165 + 0.02125d + 0.340d^2$, g-cal$_{15}$/g.

CH_4, Methane (9)

t, °C	$C_p - C_v$	γ	C_p	C_m, 0–t°
0	8.403	1.307	35.78	35.78
100	8.353	1.232	44.36	40.05
200	8.337	1.188	52.61	44.36
300	8.328	1.160	60.47	48.42
400	8.324	1.139	68.01	52.40
500	8.324	1.125	75.12	56.25
600	8.320	1.113	81.90	59.97

CH_3Cl and C_2H_5Cl (20, 56)

VARIATION OF c_p WITH t AND p

t \ $p_{atm.}$	C_2H_5Cl 0.137	C_2H_5Cl 1.37	C_2H_5Cl 2.74	t \ $p_{atm.}$	CH_3Cl 0.68	CH_3Cl 2.72	CH_3Cl 5.46	CH_3Cl 8.2
−30	0.88			−30	0.84			
0	0.92			0	0.88			
+40	1.00	1.02	1.03	+30	0.90	0.93	0.96	1.01
80	1.06	1.09	1.13	70	0.95	0.96	1.00	1.04
110		1.13	1.17	110	0.97	1.00	1.03	1.07

SATURATED VAPORS

Values of c_s, the heat required to heat the vapor through 1°C and maintain it in the saturated condition, joule per g/deg C.

	H_2O			$(C_2H_5)_2O$	
t, °C	58	93	148	0	120
c_s	−5.9	−5.0	−0.33	0.485	0.557
	C_6H_6, Benzene			H_2	
t, °C	0	120	210	−257.24	−252.7
c_s	−7.34	0	0.48	−23.2	−15.8

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THERMODYNAMIC QUANTITIES: VALUES OF THE HEAT CAPACITY, ENTROPY, HEAT CONTENT AND "THERMODYNAMIC POTENTIAL" FOR PURE SUBSTANCES BETWEEN 0 AND 298°K

W. H. Rodebush and Esther Rodebush

Contents

Heat capacity of elementary substances.
Entropy, heat content and "thermodynamic potential" for pure substances between 0 and 298°K.

Introduction

Unless otherwise indicated, the values given in this section apply in all cases to the form which is stable under 1 atm. pressure at the temperature in question.

In all cases, the mass unit is the gram-formula-weight, the energy unit is the joule, and the temperature unit is °K. The pressure is 1 atmosphere.

In all cases, the value of each of the quantities tabulated is assumed to be 0 at 0°K.

The number of units uncertain in a given place of significant figures is indicated by the number of bars over the figure in that place, one bar indicating $\pm$ 1 to 3 units, two bars, $\pm >3$ units.

C_p Heat capacity per gram-formula-weight.

S Entropy.

H Heat content. Computed from heats of formation in the case of compounds.

Matières

Capacité calorifique des substances élémentaires.
Entropie, chaleur totale et "potentiel thermodynamique" pour les substances pures entre 0 et 298°K.

Introduction

À moins d'une autre indication, les valeurs données dans cette section se rapportent dans tous les cas à la forme qui est stable sous une pression d'une atmosphère à la température en question. Dans tous les cas, l'unité de masse est le poids moléculaire, l'unité d'énergie est le joule, et l'unité de température est le degré K. La pression est 1 atmosphère.

Dans tous les cas, la valeur concernant chaque quantité mentionnée est supposée être 0 à 0°K.

Le nombre d'unités incertaines à une place donnée des chiffres significatifs est indiqué par le nombre de barres se trouvant sur le chiffre à cette place, une barre indiquant $\pm$ 1 à 3 unités, deux barres, $\pm > 3$ unités.

C_p Capacité calorifique par molécule gramme.

S Entropie.

H Chaleur totale. Calculée à partir des chaleurs de formation dans le cas des composés.

Inhaltsverzeichnis

Wärmekapazität elementarer Stoffe.
Entropie, Wärmeinhalt und "thermodynamisches Potential" für reine Stoffe zwischen 0 und 298°K.

Einleitung

Wenn nichts anderes angegeben, so beziehen sich die gegebenen Werte dieses Abschnittes in allen Fällen auf die bei 1 Atm. und der fraglichen Temperatur, stabile Form.

In allen Fällen ist die Mengeneinheit das Grammformelgewicht, die Einheit der Energie ist Joule und die für die Temperatur ist °K. Der Druck ist 1 Atmosphäre.

In allen Fällen wird angenommen, dass jede Grösse, welche in der Tabelle angegeben ist, bei 0°K selbst Null ist.

Die Zahl der Einheiten die an einer gegebenen Stelle einer gewerteten Zahl unsicher sind, werden durch die Anzahl von Strichen über der Zahl an dieser Stelle angezeigt. Ein Strich bedeutet $\pm$ 1 bis 3 Einheiten, zwei Striche $\pm$ mehr wie 3 Einheiten.

C_p Wärmekapazität pro Grammformelgewicht.

S Entropie.

H Wärmeinhalt. Berechnet aus der Bildungswärme im Falle einer Verbindung.

Indice

Calore specifico degli elementi 85
Entropia, capacità termica e "potenziale termodinamico" di corpi puri fra 0 e 298°K 87

Introduzione

I valori riportati in questo capitolo si riferiscono (a meno che non sia altrimenti indicato) alla forma stabile a pressione atmosferica e alla temperatura in questione.

In tutti i casi l'unità di massa è la grammimolecola, l'unità di energia il joule e l'unità di temperatura il °K. La pressione è 1 atmosfera.

In tutti i casi il valore delle quantità riportate nella tabella è supposto essere 0 a 0°K.

Le unità di cui è incerto un determinato numero significativo, sono indicate dal numero di linee stampate sopra la cifra stessa. Una linea indica $\pm$ da 1 a 3 unità, due linee $\pm > 3$ unità.

C_p Calore specifico per un peso in grammi corrispondente alla formula.

S Entropia.

H Capacità termica. Computata, nel caso di composti, dai calori di formazione.

HEAT CAPACITY OF ELEMENTARY SUBSTANCES BETWEEN 0 AND 300°K

DEWAR'S VALUES OF MEAN ATOMIC HEAT CAPACITY BETWEEN 77.4 AND 20.35°K (3)

Joules per gram-atom per °C

As,	7.57	Cl,	13.40	Mn,	4.94	Rh,	5.4
Au,	12.4	Co,	4.77	Mo,	5.37	Ru,	4.35
B,	0.94	Cr,	2.76	Ni,	4.77	Se,	11.19
Ba,	18.8	Cs,	26.7	Os,	5.82	Sr,	18.84
Be,	0.49	"Di,"	18.14	Pd,	7.95	Te,	14.4
Bi,	17.75	Ir,	7.53	P(r),	5.23	Th,	17.95
Br,	14.15	La,	18.0	P(y),	9.37	Ti,	3.84
Ce,	18.18	Li,	5.27	Pt,	10.3	U,	12.9
				Rb,	23.65	Zr,	9.33

A-TABLE.—ELEMENTARY SUBSTANCES

Molecular heat capacity, joules per gram-formula-weight per °C

Argon

T, °K	C_p
Solid (6)	
15	$\overline{6}.3$
21	$1\overline{4}.7$
30	$1\overline{8}.8$
36	$2\overline{2}.8$
45	$2\overline{4}.7$
60	$2\overline{7}.6$
75	$3\overline{1}.4$
Liquid (6)	
84 to 88	$4\overline{4}.0$
Gas (12)	
90	$22.\overline{2}$
100	$22.\overline{2}$
150	$22.\overline{0}$
200	$21.\overline{7}$
250	$21.\overline{4}$
300	$21.\overline{1}$

Ag (9, 19, 20)

20	$1.\overline{7}$
30	$4.\overline{3}5$
40	$8.0\overline{5}$
50	$11.\overline{1}$
60	$13.\overline{9}$
70	$15.\overline{9}$
80	$17.\overline{6}$
90	$19.\overline{0}$
100	$20.0\overline{5}$
150	$23.1\overline{5}$
200	$24.2\overline{5}$
250	$24.9\overline{5}$
300	$25.3\overline{5}$

Al (9, 20, 21)

20	$0.\overline{3}$
30	$1.\overline{1}$
40	$2.\overline{2}$
50	$3.9\overline{0}$
60	$5.8\overline{5}$
70	$7.7\overline{5}$
80	$9.4\overline{5}$
90	$11.\overline{2}$
100	$12.\overline{9}$
150	$18.\overline{5}$
200	$21.5\overline{5}$
250	$23.\overline{2}$
300	$24.\overline{5}$

C, Graphite (19)

T, °K	C_p
20	$0.\overline{1}$
30	$0.\overline{2}5$
40	$0.\overline{4}$
50	$0.\overline{6}$
60	0.75
70	$1.\overline{0}$
80	$1.1\overline{5}$
90	$1.4\overline{0}$
100	$1.\overline{6}$
150	$3.\overline{2}$
200	$5.\overline{0}$
250	$6.8\overline{5}$
300	$8.\overline{6}$

C, Diamond (20)

90	$0.0\overline{4}$
100	$.2\overline{5}$
125	$.\overline{8}$
150	$1.\overline{4}$
175	$2.\overline{0}$
200	$2.\overline{5}$
250	$4.\overline{2}$
300	$6.2\overline{5}$

Ca (4, 10)

10	$0.\overline{7}5$
20	$2.\overline{1}$
30	$4.\overline{0}$
40	$7.1\overline{5}$
50	$1\overline{0}.25$
60	$1\overline{3}.1$
70	$1\overline{5}.5$
80	$1\overline{7}.8$
90	$1\overline{9}.1$
100	$2\overline{0}.4$
150	$2\overline{4}.0$
200	$2\overline{5}.35$
250	$2\overline{5}.65$
300	$2\overline{5}.9$

Cd (9, 25)

20	$3.\overline{2}$
30	$6.\overline{9}$
40	$11.\overline{2}$
50	$15.\overline{0}$
60	$17.\overline{5}$
70	$19.3\overline{5}$
80	$30.6\overline{5}$
90	$21.\overline{6}$

Cd.—(*Cont'd*)

T, °K	C_p
100	$22.2\overline{5}$
150	$24.\overline{2}$
200	$25.1\overline{5}$
250	$25.7\overline{5}$
300	$26.\overline{2}$

Cl_2, Solid (7)

22	$1\overline{0}.0$
30	$1\overline{7}.6$
35	$2\overline{1}.8$
40	$2\overline{6}.4$
45	$2\overline{9}.7$
52	$3\overline{2}.7$
80	$3\overline{9}.8$
90	$4\overline{1}.5$
100	$4\overline{3}.1$
110	$4\overline{4}.7$
150	$5\overline{3}.6$
155	$5\overline{4}.8$

Cl_2, Liquid (7)

188 to 197	68.0

Co, *v.* p. 93

Cu (9, 14, 20)

20	$0.\overline{4}$
30	$1.\overline{7}$
40	$3.\overline{4}$
50	$5.8\overline{5}$
60	$8.\overline{1}$
70	$10.\overline{4}$
80	$12.\overline{5}$
90	$14.\overline{6}$
100	$16.\overline{3}$
150	$21.\overline{0}$
200	$22.\overline{7}$
250	$23.\overline{7}$
300	$24.\overline{6}$

Fe (9)

30	$0.\overline{6}$
40	$2.\overline{2}$
50	$4.1\overline{5}$
60	$6.\overline{1}$
70	$7.\overline{8}$
80	$9.\overline{5}5$
90	$11.\overline{2}$
100	$12.\overline{9}$
150	$18.\overline{8}$

Fe.—(*Cont'd*)

T, °K	C_p
200	$21.\overline{8}$
250	$2\overline{3}.8$
300	$25.\overline{2}$

He (2.5)

H_2, Solid (16, 31)

12	$4.1\overline{8}$

H_2, Liquid (6, 16, 31)

15 to 21	$1.\overline{3}8 + 0.\overline{8}60T$

H_2, Gas (5)

30	$2\overline{0}.8$
40	$2\overline{0}.8$
50	$2\overline{0}.8$
60	$2\overline{0}.8$
70	$2\overline{1}.1$
80	$2\overline{1}.6$
90	$2\overline{2}.2$
100	$22.\overline{8}$
150	$25.\overline{3}$
200	$26.\overline{8}$
250	$28.\overline{0}$
300	$29.\overline{1}$

Hg, Solid (1, 22, 24, 28, 29)

10	$4.\overline{8}$
20	$10.\overline{0}$
30	$15.\overline{7}$
40	$18.\overline{8}$
50	$20.\overline{9}$
60	$22.\overline{2}$
70	$23.\overline{0}$
80	$23.\overline{9}$
90	$24.\overline{1}$
100	$24.\overline{5}$
150	$26.\overline{0}$
200	$27.\overline{2}$

Hg, Liquid (33)

235 to 298	$28.\overline{0}$

$\frac{1}{2}I_2$, Solid (17)

15	$4.\overline{6}$
21	$9.\overline{8}5$
30	$12.\overline{8}$
36	$15.\overline{7}$
45	$17.\overline{6}$
60	$20.\overline{1}$
75	$21.\overline{8}$
90	$22.\overline{9}$
105	$23.\overline{4}$
120	$23.\overline{8}$
135	$24.\overline{1}$
150	$24.\overline{5}$
180	$25.\overline{1}$
200	$25.\overline{6}$
250	$26.\overline{8}$
300	$27.\overline{8}$

K (4)

10	$6.\overline{0}7$
20	$1\overline{1}.0$
30	$1\overline{5}.2$
40	$1\overline{8}.35$
50	$2\overline{0}.8$

K.—(*Cont'd*)

T, °K	C_p
60	$2\overline{2}.05$
70	$2\overline{3}.75$
80	$2\overline{4}.6$
90	$2\overline{5}.1$
100	$2\overline{5}.35$
150	$2\overline{6}.6$
200	$2\overline{7}.8$
250	$2\overline{9}.0$
300	$3\overline{0}.2$

Mg (4, 21)

20	$0.\overline{5}0$
30	$1.\overline{8}5$
40	$3.\overline{6}0$
50	$6.\overline{1}5$
60	$8.\overline{6}$
70	$10.\overline{9}5$
80	$13.\overline{1}5$
90	$15.\overline{1}$
100	$16.\overline{6}$
150	$21.4\overline{5}$
200	$23.3\overline{5}$
250	$24.\overline{4}$
300	$25.2\overline{5}$

N_2, Solid (6, 15)

NI	
15	$1\overline{2}.5$
21	$2\overline{5}.1$
30	$3\overline{0}.5$
NII	
45	$3\overline{9}.7$
51	$4\overline{2}.3$
60	$4\overline{5}.2$

N_2, Liquid (6, 15)

64 to 76	$5\overline{5}.6$

N_2, Gas (27)

80	$30.\overline{2}$
90	$30.\overline{2}$
100	$30.\overline{1}$
150	$29.\overline{9}$
200	$29.\overline{7}$
250	$29.\overline{5}$
300	$29.\overline{1}$

Na (9, 11, 30)

20	$2.\overline{5}$
30	$5.\overline{2}5$
40	$9.\overline{1}$
50	$1\overline{3}.4$
60	$1\overline{6}.75$
70	$1\overline{8}.95$
80	$2\overline{0}.6$
90	$2\overline{1}.55$
100	$2\overline{2}.25$
150	$2\overline{4}.8$
200	$2\overline{6}.3$
250	$2\overline{7}.4$
300	$2\overline{8}.55$

O_2, Solid (6)

OI	
15	$\overline{9}.20$
18	$1\overline{1}.25$
21	$1\overline{6}.7$

O_2, Solid.—(*Cont'd*)

T, °K	C_p
OII	
30	$2\overline{7}.9$
36	$3\overline{6}.8$
39	$4\overline{1}.8$
OIII	
46	$4\overline{5}.2$

O_2, Liquid (6)

57 to 73	$5\overline{3}.2$

O_2, Gas (27)

90	$32.\overline{6}$
100	$32.\overline{4}$
150	$29.\overline{4}$
200	$29.\overline{7}$
250	$28.\overline{4}$
300	$29.\overline{4}$

Pb (8, 9, 13, 19)

20	$11.\overline{1}$
30	$16.\overline{6}5$
40	$19.\overline{9}$
50	$22.\overline{0}$
60	$22.\overline{7}5$
70	$23.\overline{4}$
80	$23.\overline{9}$
90	$24.\overline{2}$
100	$24.\overline{4}5$
150	$25.\overline{1}$
200	$25.\overline{4}5$
250	$25.\overline{9}$
300	$26.\overline{4}$

Pd, *v.* p. 93

S, Rhombic (19)

10	$1.\overline{3}$
20	$3.\overline{0}$
30	$4.\overline{8}$
40	$6.1\overline{5}$
50	$7.\overline{4}$
60	$8.\overline{7}$
70	$9.\overline{9}5$
80	$11.\overline{2}$
90	$12.\overline{3}$
100	$13.\overline{4}$
150	$17.\overline{2}$
200	$19.\overline{6}$
250	$21.\overline{4}5$
300	$23.\overline{3}$

S, Monoclinic (19)

83	$1\overline{1}.55$
87	$1\overline{2}.15$
91	$1\overline{2}.4$
97	$1\overline{2}.45$
102	$1\overline{3}.2$
194	$2\overline{0}.6$
200	$2\overline{0}.95$

Sb (11)

80.4	21.7
81.6	21.2
83.7	21.1
85.6	21.8
86.2	21.8
92.0	22.3
93.3	22.4
98.1	22.9

Si [21]

T, °K	C_p
20	0.08
30	.50
40	1.1
50	1.9
60	2.85
70	3.0
80	5.1
90	6.45
100	7.9
150	13.5
200	16.2
250	18.4
300	20.35

Sn, Gray [2, 17, 25]

T, °K	C_p
10	1.5
20	3.55
30	6.4
40	8.9
50	11.2
60	13.15
70	15.2
80	16.9
90	18.2
100	19.58
150	23.05
200	24.4
250	25.2
300	25.85

Sn, White [2, 17, 25]

T, °K	C_p
10	1.9
20	4.4
30	8.6
40	12.4
50	15.3
60	17.3
70	18.95
80	20.6
90	21.55
100	22.5
150	25.0
200	25.95
250	26.55
300	26.95

Ta, *v.* p. 94

Te, *v.* p. 94

Ti, *v.* p. 94

Tl [21]

T, °K	C_p
20	8.65
30	15.0
40	18.2
50	20.3
60	21.8
70	22.8
80	23.45
90	23.8
100	24.15
150	25.2
200	25.5

Tl.—*(Cont'd)*

T, °K	C_p
250	26.35
300	26.8

W [17]

T, °K	C_p
10	0.1
20	0.7
30	1.7
40	3.05
50	5.75
60	8.25
70	10.75
80	12.95
90	14.9
100	16.55
150	21.0
200	23.05
250	24.4
300	25.55

Zn [9, 19, 23]

T, °K	C_p
30	3.5
40	7.20
50	10.35
60	13.1
70	15.3
80	17.1
90	18.5
100	19.8
150	22.95
200	24.05
250	24.9
300	25.4

NH₃, Liquid [7]

T, °K	C_p
200	77.0
210	76.4
220	76.1

CO, Solid [6, 27]

T, °K	C_p
CO_I	
10	4.8
20	14.2
30	24.7
40	34.4
50	45.4
57	56.5
CO_{II}	
65	52.8

CO, Liquid [6]

T, °K	C_p
67 to 83	7.2

CO, Gas [27]

T, °K	C_p
83	30.4
90	30.3
100	30.2
150	30.0
200	29.7
250	29.5
300	29.3

CH_4, Solid [7]

T, °K	C_p
30	23.1
40	28.5
55	33.95
70	38.1
80	41.2
85	42.7

CH_4, Liquid [7]

T, °K	C_p
96	57.5

CH_4, Liquid.—*(Cont'd)*

T, °K	C_p
100	56.6
105	56.6

C_6H_6 [18, 19, 32]

T, °K	C_p
10	2.5
20	8.55
30	17.6
40	26.1
50	32.2
60	38.7
70	43.8
80	49.2
90	53.8
100	57.8
150	78.0
200	95.5
250	112.0
300	127.1

CO_2 [6]

T, °K	C_p	T, °K	C_p
19.4	4.52	82.75	37.6
22.0	6.03	84.2	38.2
23.45	7.4	85.5	38.8
25.4	8.62	86.4	38.4
26.4	9.87	88.4	38.9
29.3	11.9	195.2	54.2
31.8	13.72	195.3	54.5
34.7	16.31	196.4	54.4
37.8	18.33	197.1	55.4
41.3	21.25	198.0	55.3
44.2	22.85	198.9	55.2
80.15	37.0	199.6	55.6
82.0	37.25	200.5	56.0

$(C_5H_8O)_x$, Ketone resin [28]

67.3	34.5	155.3	73.0
72.5	38.1	158.2	74.6
73.4	37.7	203.4	92.0
76.9	40.8	205.4	91.0
78.3	40.1	216.9	97.0
81.5	43.1	218.8	98.4
93.1	48.0	269.9	119.7
97.5	49.6	296.9	132.8
129.0	64.6	298.4	135.8
132.2	64.4		

$C_6H_{12}O_6$, Glucose [28]

19.9	4.96	90.6	42.1
23.4	6.74	100.6	46.3
26.9	8.78	102.1	46.3
31.4	11.71	105.4	48.1
36.0	14.36	114.1	51.1
39.2	16.3	130.9	58.4
44.2	18.16	153.7	67.6
48.8	21.75	158.0	69.6
51.8	23.5	200.1	86.9
56.0	25.9	202.5	88.7
60.9	28.8	231.5	101.8
66.5	31.4	251.9	110.0
69.8	32.6	269.9	119.5
79.2	37.0	287.2	126.2
84.6	39.6	296.2	135.0

ℬ-Table.—Chemical Compounds; *v. also* p. 89.

Standard Arrangement (*v.* Vol. III, p. viii)

HCl, Solid [7]; *cf.* [34]

T, °K	C_p
HCl_I	
25	8.95
30	11.95
35	14.25
40	16.9
45	18.85
50	20.5
55	21.95
60	23.35
70	26.35
80	29.0
90	31.9
HCl_{II}	
105	40.6
110	41.8
135	46.7
145	48.7
155	50.5

HCl, Liquid [7]; *cf.* [34]

165	62.2
175	63.1
185	64.0

HBr, Solid [7]; *cf.* [35]

T, °K	C_p
HBr_I	
22	12.6
25	15.4
30	17.5

HBr, Solid.—*(Cont'd)*

T, °K	C_p
HBr_I	
40	22.55
50	26.15
60	29.25
70	33.8
80	44.6
HBr_{II}	
95	43.6
105	48.4
110	51.4
HBr_{III}	
120	47.7
135	47.7

HBr, Liquid [7]; *cf.* [35]

190 to 198	60.7

HI, Solid [7]

T, °K	C_p
HI_I	
60	38.95
65	50.0
HI_{II}	
85	43.2
100	45.0
HI_{III}	
140	48.0
155	47.3
160	47.1

HI, Solid.—*(Cont'd)*

T, °K	C_p
HI_{III}	
170	47.1
180	46.8
200	47.5

HI, Liquid [7]

224 to 238	68.6

NO, Solid [7]

T, °K	C_p
25	10.1
30	12.6
80	31.5
85	33.1
90	34.4
100	36.4

NO, Liquid [7]

115 to 117	72.7

NH_3, Solid [7]

T, °K	C_p
25	2.9
30	4.6
40	8.5
50	12.6
85	23.5
100	27.7
130	32.2
150	40.7
170	45.3
185	49.0

PbI_2 [21]

T, °K	C_p	T, °K	C_p
22.3	29.5	89.4	71.5
26.2	32.85	95.6	72.3
38.2	44.9	235.0	784.0
50.6	55.2	332.0	823.0
62.1	61.8		

Hg_2SO_4 [24]

23.5	25.2	76.6	68.2
26.5	34.2	85.0	71.5
30.0	39.4	201.0	108.9
56.2	58.9	290.0	129.2

BeO [10]

76.8	0.85	79.7	1.02
78.1	.92	80.3	0.93
78.6	.82	82.6	0.99
79.3	.95	84.9	1.15

$Ca(OH)_2$ [21]

21.4	2.06	47.4	6.96
26.3	2.94	50.4	9.63
31.4	3.42	53.8	12.34
37.6	4.54	76.2	16.95
40.7	5.38	86.0	21.3

CaH_2 [10]

69.9	7.5	80.1	9.92
71.2	7.78	80.9	9.92
72.5	7.95	86.2	11.48
79.0	9.42		

$CaCO_3$, Aragonite [10]

23.3	0.97	38.6	4.05
26.8	1.16	41.7	5.34
29.7	1.53	47.7	7.7
31.9	2.18	50.5	9.3
34.1	2.86	52.6	10.42
35.9	3.54	56.2	10.85

$Al_2(SO_4)_3K_2SO_4.24H_2O$ [21]

25.7	116.5	41.7	252.3
28.3	136.1	46.0	302.5
30.0	144.2	50.6	350.0
31.2	158.8	54.0	368.5
32.8	175.5	71.9	503.0
34.7	181.8	84.4	592.0
36.0	210.0	90.5	693.0

ENTROPY, HEAT CONTENT AND THERMODYNAMIC POTENTIAL

A-Table.—Elementary Substances

Argon [6, 12]

T, °K	C_p	S	H	$F = H - TS$
0	0	0	0	0
50	2.85	23.4	712	− 468
100	22.4	130.4	3 035	−10 005
150	21.75	139.4	4 145	−16 735
200	21.55	145.6	5 240	−22 860
250	21.35	150.4	6 320	−31 280
273.1	21.30	152.0	6 800	−34 700
298.1	21.23	154.0	7 340	−38 560

Ag [9, 19, 20]

50	11.3	5.91	192	− 103
100	20.2	17.2	1 012	− 708
150	23.2	26.0	2 095	− 1 805
200	24.4	32.8	3 280	− 3 280
250	25.0	38.3	4 520	− 5 060
273.1	25.2	40.5	5 100	− 5 970
298.1	25.3	42.7	5 730	− 6 990

Al [9, 20, 21]

0	0	0	0	0
50	3.75	1.23	52.1	− 9.4
100	13.1	6.82	465.0	− 217
150	18.63	13.22	1 272	− 710
200	21.55	18.98	2 285	− 1 505
250	23.23	23.95	3 500	− 2 480
273.1	23.85	26.1	4 040	− 3 080
298.1	24.4	28.15	4 630	− 3 750

C, Graphite [19]

0	0	0	0	0
50	0.54	0.29	11.9	− 2.8
100	1.72	1.04	73.3	− 31
150	3.26	1.97	189	− 107
200	5.10	3.18	394	− 242
250	6.94	4.44	688	− 422
273.1	7.82	5.10	856	− 536
298.1	8.66	5.81	1 052	− 678

C, Diamond [20]

0	0	0	1 282	1 282
50	0	0	1 282	1 282
100	0.29	0.063	1 282	1 276
150	1.13	.34	1 326	1 276
200	2.34	.80	1 426	1 266
250	4.18	1.45	1 589	1 227
273.1	5.02	1.82	1 698	1 207
298.1	6.19	2.28	1 806	1 126

Ca (4, 10)

T, °K	C_p	S	H	$F = H - TS$
50	1.46	5.58	189	− 90
100	2.70	7.1	983	− 727
150	4.0	6.2	2 110	− 1 810
200	5.3	8.3	3 340	− 3 310
250	5.8	9.1	4 620	− 5 150
273.1	5.88	1.3	5 220	− 6 060
298.1	5.97	3.5	5 860	− 7 120

Cd (9, 25)

0	0	0	0	0
50	5.4	8.12	285.5	− 121
100	2.45	2.7	1 290	− 980
150	4.18	2.15	2 460	− 2 360
200	5.15	9.2	3 700	− 4 140
250	5.65	4.3	4 960	− 6 130
273.1	5.9	6.7	5 560	− 7 190
298.1	6.1	8.9	6 210	− 8 390

Cu (9, 14, 20)

50	6.02	2.47	82.2	− 41
100	6.07	0.03	648.0	− 355
150	0.85	7.52	1 603	− 1 025
200	2.9	4.0	2 700	− 2 100
250	3.95	9.25	3 860	− 3 450
273.1	4.20	1.35	4 420	− 4 130
298.1	4.45	3.60	5 020	− 4 990

Fe (9)

0	0	0	0	0
50	3.77	1.30	50.2	− 15
100	3.1	6.78	484	− 192
150	8.82	3.27	1 292	− 698
200	1.85	9.12	2 302	− 1 522
250	3.85	4.20	3 455	− 2 595
273.1	4.45	6.4	4 010	− 2 190
298.1	5.1	8.6	4 630	− 3 900

½H₂ (5, 16, 31)

0	0	0	0	0
50	0.45	2.25	90	− 1 225
100	1.3	9.7	1 430	− 3 540
150	2.58	4.5	2 035	− 6 135
200	3.4	8.4	2 685	− 8 995
250	4.03	1.4	3 360	−11 990
273.1	4.3	2.5	3 690	−13 370
298.1	4.53	4.0	4 050	−15 050

Hg (1, 22, 24, 28, 29)

0	0	0	0	0
50	0.9	1.7	602	− 483
100	4.65	7.6	1 768	− 1 992
150	6.2	7.8	3 040	− 4 140
200	7.2	5.4	4 380	− 6 680
273.1	8.0	4.2	7 800	−12 500
298.1	7.6	6.5	8 500	−14 300

½I₂ (17)

T, °K	C_p	S	H	$F = H - TS$
0	0	0	0	0
50	8.41	6.30	495	− 320
100	3.2	1.05	1 578	− 1 527
150	4.4	0.7	2 770	− 3 330
200	5.65	7.8	4 030	− 5 520
250	6.9	3.7	5 340	− 8 060
273.1	7.35	5.9	5 960	− 9 330
298.1	7.8	8.4	6 650	−10 750

K (4, 30)

50	1.6	9.55	607	− 369
100	5.3	6.0	1 795	− 1 805
150	6.65	9.5	3 090	− 4 330
200	7.90	7.4	4 450	− 7 010
250	9.2	3.7	5 880	−10 020
273.1	9.6	6.3	6 560	−11 540
298.1	0.15	9.0	7 320	−13 280

Mg (4, 21)

50	6.27	2.47	90.5	− 33
100	6.5	0.4	680	− 360
150	1.2	7.95	1 650	− 1 040
200	3.6	4.3	2 780	− 2 090
250	4.95	9.6	3 970	− 3 430
273.1	5.2	1.8	4 540	− 4 140
298.1	5.45	4.0	5 170	− 4 980

½N₂ (6, 15, 27)

0	0	0	0	0
50	1.15	3.15	706	− 452
100	5.0	0.01	4 940	− 3 061
150	4.8	6.0	5 710	− 7 190
200	4.7	0.4	6 450	−11 610
250	4.65	3.5	7 180	−16 170
273.1	4.62	4.9	7 520	−18 380
298.1	4.6	6.1	7 890	−20 730

Na (9, 11, 30)

0	0	0	0	0
50	3.4	6.49	241	− 83
100	3.0	9.2	1 177	− 743
150	5.77	3.3	2 370	− 2 630
200	7.05	1.0	3 650	− 4 550
250	7.85	7.2	4 990	− 6 810
273.1	8.15	9.7	5 620	− 7 930
298.1	8.4	2.2	6 330	− 9 190

½O₂ (6, 27)

0	0	0	0	0
50	2.6	6.2	965	− 345
100	5.1	4.9	5 720	− 2 770
150	4.5	0.6	6 470	− 7 130
200	4.33	4.9	7 180	−11 810
250	4.43	8.0	7 890	−16 610
273.1	4.53	9.4	8 230	−18 870
298.1	4.63	0.5	8 600	−21 400

Pb (8, 9, 13, 19, 30)

T, °K	C_p	S	H	$F = H - TS$
0	0	0	0	0
50	2$\bar{1}$.62	2$\bar{1}$.1	5$\bar{7}$7	− 4$\bar{7}$8
100	2$\bar{3}$.7	3$\bar{7}$.2	1 7$\bar{5}$3	− 1 9$\bar{6}$7
150	2$\bar{5}$.4	4$\bar{7}$.3	2 9$\bar{8}$5	− 4 $\bar{1}$15
200	2$\bar{5}$.9	5$\bar{4}$.6	4 2$\bar{5}$0	− 6 6$\bar{5}$0
250	2$\bar{6}$.25	6$\bar{0}$.5	5 $\bar{5}$40	− 9 $\bar{5}$80
273.1	26.$\bar{3}$5	6$\bar{2}$.8	6 $\bar{1}$40	−10 $\bar{9}$90
298.1	26.$\bar{5}$	6$\bar{5}$.0	6 $\bar{8}$00	−12 $\bar{6}$00

S, Orthorhombic (19)

0	0	0	0	0
50	7.$\bar{8}\bar{2}$	6.$\bar{2}$	1$\bar{8}\bar{2}$	− 1$\bar{2}\bar{8}$
100	1$\bar{2}$.8$\bar{5}$	1$\bar{3}$.$\bar{2}$	$\bar{6}\bar{0}\bar{5}$	− $\bar{7}\bar{1}\bar{5}$
150	1$\bar{6}$.$\bar{5}$	1$\bar{9}$.1	1 3$\bar{7}$0	− 1 4$\bar{9}$0
200	1$\bar{9}$.1$\bar{2}$	2$\bar{4}$.$\bar{3}$	2 2$\bar{9}$0	− 2 $\bar{5}$70
250	2$\bar{1}$.$\bar{4}$	2$\bar{8}$.$\bar{8}$	3 3$\bar{1}$0	− 3 $\bar{8}$90
273.1	2$\bar{2}$.1$\bar{7}$	3$\bar{0}$.$\bar{2}$	3 $\bar{8}$10	− 4 $\bar{4}$30
298.1	2$\bar{3}$.$\bar{0}$	3$\bar{2}$.$\bar{2}$	4 3$\bar{8}$0	− 5 $\bar{2}\bar{2}$0

Si (21)

0	0	0	0	0
50	1.$\bar{9}\bar{3}$	0.$\bar{7}$1	2$\bar{8}$.15	− $\bar{7}$.4
100	$\bar{7}$.8$\bar{3}$	3.$\bar{8}$1	2$\bar{6}\bar{5}$.5	− 1$\bar{1}$5.5
150	1$\bar{2}$.55	7.$\bar{9}$1	$\bar{8}\bar{0}$1	− 3$\bar{8}\bar{6}$
200	1$\bar{5}$.57	1$\bar{1}$.85	1 $\bar{5}$58	− $\bar{8}\bar{1}\bar{2}$
250	1$\bar{8}$.0	1$\bar{5}$.6	2 3$\bar{9}$0	− 1 $\bar{5}$10
273.1	1$\bar{8}$.9	1$\bar{7}$.3	2 $\bar{8}$05	− 1 $\bar{9}$15
298.1	1$\bar{9}$.99	1$\bar{9}$.0	3 3$\bar{0}$0	− 2 $\bar{3}$60

Sn, White (2, 17, 25)

0	0	0	0	0
50	15.$\bar{3}\bar{5}$	1$\bar{1}$.12	3$\bar{5}\bar{4}$	− 2$\bar{0}\bar{2}$
100	22.$\bar{4}\bar{5}$	2$\bar{4}$.4	1 3$\bar{2}$4	− 1 $\bar{1}$16
150	25.$\bar{0}$	3$\bar{4}$.0	2 $\bar{5}$20	− 2 $\bar{5}$80
200	26.$\bar{1}$	4$\bar{1}$.5	3 $\bar{8}$10	− 4 $\bar{4}$90
250	26.$\bar{6}$	4$\bar{7}$.4	5 $\bar{1}$40	− 6 $\bar{7}$10
273.1	26.$\bar{8}$	4$\bar{9}$.6	5 $\bar{7}$60	− 7 $\bar{7}$70
298.1	26.$\bar{9}$	5$\bar{2}$.3	6 $\bar{4}$40	− 9 $\bar{1}$60

Sn, Gray (2, 17, 25)

0	0	0	− 1 $\bar{5}$50	− 1 $\bar{5}$50
50	11.$\bar{1}\bar{3}$	8.$\bar{1}\bar{2}$	− 1 $\bar{5}$25	− 1 $\bar{9}$30
100	19.$\bar{6}$	18.$\bar{7}$	− $\bar{5}\bar{1}\bar{0}$	− 2 $\bar{3}$80
150	23.$\bar{0}$	2$\bar{7}$.3	$\bar{5}\bar{6}\bar{0}$	− 3 $\bar{5}$40
200	24.$\bar{6}$	3$\bar{4}$.8	1 $\bar{7}$50	− 5 $\bar{2}$00
250	25.$\bar{4}$	4$\bar{0}$.5	2 $\bar{9}$90	− 7 $\bar{1}$30
273.1	25.$\bar{5}\bar{5}$	4$\bar{2}$.7	3 $\bar{5}$70	− 8 $\bar{0}$80
298.1	25.$\bar{6}$	4$\bar{4}$.7	4 $\bar{1}$80	− 9 $\bar{1}$20

Tl (21)

50	20.$\bar{7}$	18.$\bar{4}$	$\bar{5}\bar{2}\bar{4}$	− $\bar{3}\bar{9}\bar{6}$
100	24.0$\bar{5}$	3$\bar{4}$.$\bar{2}$	1 $\bar{6}\bar{6}\bar{0}$	− 1 $\bar{7}\bar{6}\bar{0}$
150	2$\bar{5}$.$\bar{2}$	4$\bar{4}$.$\bar{2}$	2 $\bar{8}\bar{9}\bar{0}$	− 3 $\bar{7}\bar{4}\bar{0}$
200	2$\bar{5}$.8$\bar{5}$	5$\bar{1}$.$\bar{5}$	4 1$\bar{7}\bar{0}$	− 6 1$\bar{3}\bar{0}$
250	26.$\bar{3}$	5$\bar{7}$.$\bar{5}$	5 $\bar{4}\bar{7}\bar{0}$	− 8 $\bar{9}\bar{2}\bar{0}$
273.1	26.$\bar{5}$	5$\bar{9}$.$\bar{7}$	6 $\bar{0}\bar{8}\bar{0}$	−10 $\bar{2}\bar{0}\bar{0}$
298.1	26.6$\bar{5}$	6$\bar{2}$.$\bar{2}$	6 $\bar{7}$50	−11 $\bar{7}\bar{7}\bar{0}$

W (17)

T, °K	C_p	S	H	$F = H - TS$
50	6.$\bar{0}\bar{2}$	$\bar{2}$.43	8$\bar{3}$.6	− $\bar{3}\bar{8}$
100	16.$\bar{3}\bar{2}$	1$\bar{0}$.09	$\bar{6}\bar{7}\bar{2}$	− $\bar{3}\bar{3}\bar{7}$
150	2$\bar{1}$.15	1$\bar{7}$.69	1 $\bar{6}$25	− 1 $\bar{0}$25
200	2$\bar{3}$.55	2$\bar{4}$.1	2 $\bar{7}$30	− 2 $\bar{0}\bar{9}\bar{0}$
250	2$\bar{4}$.9	2$\bar{9}$.6	3 $\bar{9}$20	− 3 $\bar{4}\bar{8}\bar{0}$
273.1	2$\bar{5}$.2	3$\bar{1}$.7	4 $\bar{4}$90	− 4 $\bar{1}\bar{6}\bar{0}$
298.1	2$\bar{5}$.55	3$\bar{3}$.90	5 $\bar{1}$20	− 4 $\bar{9}\bar{8}\bar{0}$

Zn (9, 19, 23)

0	0	0	0	0
50	10.$\bar{2}\bar{7}$	4.$\bar{8}\bar{2}$	1$\bar{4}\bar{1}$	− 1$\bar{0}\bar{0}$
100	19.$\bar{7}\bar{5}$	1$\bar{5}$.38	9$\bar{2}\bar{4}$	− 6$\bar{1}\bar{4}$
150	23.$\bar{0}$	2$\bar{3}$.55	2 $\bar{0}$10	− 1 $\bar{5}$20
200	24.$\bar{3}$	3$\bar{0}$.3	3 $\bar{1}$95	− 2 $\bar{8}\bar{6}\bar{5}$
250	24.$\bar{9}$	3$\bar{5}$.85	4 $\bar{4}$20	− 4 $\bar{5}\bar{4}\bar{0}$
273.1	25.$\bar{1}\bar{5}$	3$\bar{8}$.45	5 $\bar{0}$00	− 5 $\bar{5}$00
298.1	25.$\bar{2}\bar{5}$	4$\bar{0}$.6	5 $\bar{6}$30	− 6 $\bar{4}$70

$\mathfrak{B}$-Table.—Chemical Compounds, Standard Arrangement

H_2O (24)

0	0	0	−28$\bar{2}$ 600	−28$\bar{2}$ 600
50	8.$\bar{5}\bar{8}$	4.$\bar{7}\bar{8}$	−28$\bar{2}$ 417	−28$\bar{2}$ 656
100	1$\bar{6}$.1	13.$\bar{3}$1	−28$\bar{1}$ 777	−28$\bar{3}$ 108
150	2$\bar{1}$.75	2$\bar{0}$.8	−28$\bar{0}$ 825	−28$\bar{3}$ 945
200	2$\bar{3}$.85	2$\bar{7}$.75	−27$\bar{9}$ 595	−28$\bar{5}$ 145
250	3$\bar{4}$.7	3$\bar{4}$.65	−27$\bar{8}$ 060	−28$\bar{6}$ 720
273.1	38.$\bar{2}$	3$\bar{7}$.85	−27$\bar{7}$ 220	−28$\bar{7}$ 540
298.1	75.$\bar{3}$	6$\bar{6}$.7	−26$\bar{9}$ 300	−28$\bar{9}$ 200

HCl (34); **HBr** (35)

NH_4Cl (28)

0	0	0	−28$\bar{5}$ 960	−28$\bar{5}$ 960
50	1$\bar{4}$.69	6.$\bar{4}\bar{9}$	−28$\bar{5}$ 706	−28$\bar{6}$ 031
100	3$\bar{7}$.7	2$\bar{4}$.2	−28$\bar{4}$ 360	−28$\bar{6}$ 780
150	5$\bar{0}$.2	4$\bar{1}$.5	−28$\bar{2}$ 100	−28$\bar{8}$ 320
200	6$\bar{9}$.4	5$\bar{8}$.8	−27$\bar{9}$ 070	−29$\bar{0}$ 830
250	7$\bar{8}$.9	8$\bar{3}$.1	−27$\bar{4}$ 130	−29$\bar{4}$ 930
273.1	8$\bar{2}$.4	9$\bar{0}$.2	−27$\bar{2}$ 320	−29$\bar{6}$ 920
298.1	8$\bar{6}$.6	9$\bar{7}$.6	−27$\bar{0}$. 230	−29$\bar{9}$ 430

CO (6, 27)

0	0	0	−12$\bar{5}$ 948	−12$\bar{5}$ 948
50	4$\bar{5}$.2	3$\bar{0}$.75	−12$\bar{4}$ 918	−12$\bar{6}$ 458
100	32.$\bar{0}$	15$\bar{9}$.3	−11$\bar{5}$ 218	−13$\bar{1}$ 148
150	29.$\bar{9}$	17$\bar{1}$.9	−11$\bar{3}$ 718	−13$\bar{9}$ 518
200	29.6$\bar{5}$	18$\bar{0}$.0	−11$\bar{2}$ 228	−14$\bar{8}$ 228
250	29.$\bar{4}\bar{5}$	18$\bar{6}$.5	−11$\bar{0}$ 748	−15$\bar{7}$ 348
273.1	29.$\bar{4}$	18$\bar{9}$.2	−11$\bar{0}$ 068	−16$\bar{1}$ 668
298.1	29.$\bar{3}\bar{5}$	19$\bar{2}$.0	−10$\bar{9}$ 348	−16$\bar{6}$ 548

C_6H_6 (18, 19, 32)

0	0	0	4$\bar{9}$ 050	4$\bar{9}$ 050
50	3$\bar{4}$.65	2$\bar{2}$.8	4$\bar{9}$ 656	4$\bar{8}$ 516
100	5$\bar{5}$.8	5$\bar{3}$.5	5$\bar{2}$ 000	4$\bar{6}$ 650
150	7$\bar{3}$.9	7$\bar{9}$.5	5$\bar{5}$ 390	4$\bar{3}$ 490

C_6H_6.—(*Continued*)

T, °K	C_p	S	H	$F = H - TS$
200	103.0	102.5	59 670	39 170
250	110.5	124.4	64 850	33 750
273.1	118.8	135.0	67 500	30 700
298.1	133.5	181.0	80 850	26 850

SiC [10, 21]

PbO [21]

0	0	0	−213 660	−213 660
50	16.6	12.3	−213 250	−213 865
100	28.45	27.6	−212 110	−214 870
150	36.55	43.5	−210 485	−217 005
200	41.8	54.6	−208 540	−219 440
250	44.9	64.2	−206 390	−222 390
273.1	46.1	68.5	−205 320	−224 020
298.1	47.2	72.5	−204 140	−225 740

$PbCl_2$ [19]

0	0	0	−329 460	−329 460
50	40.9	29.6	−328 556	−330 036
100	59.2	64.9	−325 945	−332 435
150	68.0	90.7	−322 700	−336 300
200	72.6	111.0	−319 180	−341 380
250	75.4	127.2	−315 540	−347 340
273.1	76.2	134.1	−313 780	−350 380
298.1	76.9	140.9	−311 880	−353 880

PbS [4]

0	0	0	− 93 860	− 93 860
50	26.8	19.5	− 93 254	− 94 229
100	39.6	43.0	− 91 542	− 95 842
150	44.4	60.0	− 89 420	− 98 420
200	47.5	73.3	− 87 120	−101 770
250	49.7	84.0	− 84 710	−105 710
273.1	50.4	88.4	− 83 540	−107 640
298.1	51.4	92.8	− 82 260	−109 960

TlCl [24]

0	0	0	−191 020	−191 020
50	33.95	27.4	−190 163	−191 533
100	44.7	54.8	−188 136	−193 616
150	48.2	73.6	−185 800	−196 800
200	50.3	87.5	−183 350	−200 850
250	51.8	99.9	−180 520	−205 520
273.1	52.4	103.3	−179 320	−207 520
298.1	53.0	108.0	−178 000	−210 200

ZnS [10]

0	0	0	−190 750	−190 750
50	14.59	7.99	−190 465	−190 865
100	25.8	21.7	−189 376	−191 546
150	33.5	33.4	−187 715	−192 715
200	38.95	43.8	−185 790	−194 540
250	43.1	52.8	−183 710	−196 910
273.1	45.0	56.7	−182 680	−198 160
298.1	46.6	60.6	−181 500	−199 500

HgO [10]

0	0	0	− 83 020	− 83 020
50	18.18	12.13	− 82 631	− 83 236
100	29.3	28.45	− 81 409	− 84 254
150	36.0	41.7	− 79 725	− 85 975
200	40.3	52.5	− 77 810	− 88 310
250	43.4	61.8	− 75 840	− 91 290
273.1	44.5	65.6	− 74 830	− 92 730
298.1	45.3	69.6	− 73 700	− 94 500

HgCl [24]

0	0	0	−115 500	−115 500
50	28.6	21.3	−114 814	−115 879
100	39.55	45.0	−113 075	−117 575
150	45.0	62.3	−110 960	−120 300
200	48.0	75.7	−108 660	−123 760
250	50.0	86.5	−106 250	−127 850
273.1	50.5	90.9	−105 090	−129 890
298.1	51.0	95.4	−103 820	−132 220

CuI [28]

0	0	0	− 68 520	− 68 520
50	28.05	19.2	− 67 892	− 68 852
100	41.9	43.7	− 66 080	− 70 450
150	47.1	61.6	− 63 830	− 73 080
200	50.0	75.5	− 61 420	− 76 520
250	52.1	86.8	− 58 870	− 80 570
273.1	53.0	91.4	− 57 690	− 82 590
298.1	53.8	96.0	− 56 330	− 84 930

AgCl [19, 21]

0	0	0	−114 090	−114 090
50	28.15	20.8	−113 408	−114 448
100	41.0	45.0	−111 650	−116 150
150	46.0	62.8	−109 490	−118 920
200	49.0	76.4	−107 110	−122 390
250	51.4	87.5	−104 620	−126 495
273.1	53.1	92.1	−103 410	−128 510
298.1	53.8	96.7	−102 090	−130 890

AgI [21]

0	0	0	− 63 220	− 63 220
50	31.9	28.65	− 62 388	− 63 820
100	45.7	55.7	− 60 390	− 65 960
150	50.8	75.4	− 58 010	− 69 310
200	52.7	90.0	− 55 480	− 73 480
250	53.8	102.0	− 52 640	− 78 140
273.1	54.1	106.4	− 51 440	− 80 540
298.1	54.4	111.3	− 50 120	− 83 320

FeS_2 [8]

0	0	0	−144 750	−144 750
50	2.64	0.83	−144 720	−144 761
100	18.84	7.11	−144 226	−144 937
150	36.66	18.4	−142 870	−145 630
200	49.59	30.75	−140 680	−146 830
250	57.3	42.7	−137 990	−148 640
273.1	60.0	47.8	−136 630	−149 730
298.1	62.1	53.0	−135 100	−150 900

MgO (10, 26)

T, °K	C_p	S	H	$F = H - TS$
0	0	0	−600 680	−600 680
50	0.42	0.29	−600 660	−600 674
100	6.91	2.18	−600 497	−600 715
150	19.3	7.45	−599 822	−600 940
200	27.65	14.10	−598 590	−601 410
250	34.35	21.0	−597 010	−602 260
273.1	36.9	24.2	−596 180	−602 780
298.1	39.6	27.5	−595 230	−603 430

CaO (21)

0	0	0	−627 740	−627 740
50	2.85	0.88	−627 705	−627 749
100	16.4	6.56	−627 251	−627 907
150	28.8	15.4	−626 070	−628 370
200	37.3	24.75	−624 460	−629 400
250	41.3	33.4	−622 570	−630 920
273.1	42.9	37.18	−621 620	−631 770
298.1	44.2	40.8	−620 540	−632 740

CaF_2 (8)

0	0	0		
50	4.27	1.59		
100	19.3	8.99		
150	31.4	18.99		
200	38.1	29.95		
250	42.5	37.85		
273.1	44.0	41.7		
298.1	45.1	45.6		

$CaCO_3$, Calcite (21)

0	0	0	−1 191 410	−1 191 410
50	15.9	7.07	−1 191 118	−1 191 468
100	41.1	25.7	−1 189 690	−1 192 260
150	57.4	45.8	−1 187 260	−1 194 140
200	68.1	63.6	−1 184 250	−1 196 950
250	75.6	79.2	−1 180 710	−1 200 510
273.1	78.2	85.9	−1 178 990	−1 202 390
298.1	80.4	92.6	−1 177 000	−1 204 600

LiH (11)

0	0	0		
50	0.84	0.25		
100	6.28	2.09		
150	14.68	6.19		
200	23.3	11.68		
250	30.3	17.6		
273.1	32.35	20.45		
298.1	34.5	23.55		

NaCl (20)

T, °K	C_p	S	H	$F = H - TS$
0	0	0	−396 520	−396 520
50	15.08	6.15	−396 263	−396 570
100	34.95	23.75	−394 866	−397 241
150	42.7	39.7	−392 910	−398 860
200	46.7	52.6	−390 720	−401 220
250	49.0	63.2	−388 390	−404 190
273.1	49.6	67.6	−387 270	−405 770
298.1	50.0	72.0	−386 000	−407 400

KBr (20)

0	0	0	−386 190	−386 190
50	29.5	16.14	−385 587	−386 397
100	42.6	42.1	−383 675	−387 885
150	46.8	60.2	−381 440	−390 490
200	48.9	74.1	−379 090	−393 890
250	50.6	85.0	−376 660	−397 860
273.1	51.3	89.5	−375 480	−399 880
298.1	51.8	94.2	−374 220	−402 220

KCl (20)

0	0	0	−421 300	−421 300
50	21.1	9.71	−420 914	−421 399
100	39.6	31.0	−419 319	−422 419
150	45.1	50.2	−417 190	−424 720
200	47.7	63.5	−414 860	−427 560
250	49.4	74.2	−412 400	−430 900
273.1	50.1	78.6	−411 280	−432 700
298.1	50.6	83.1	−410 000	−434 780

$Al_2(SO_4)_3Cs_2SO_4.12H_2O$ (36)

LITERATURE

(For a key to the periodicals see end of volume)

(1) Bridgman, *65*, **47**: 345; 11. (2) Brönsted, *7*, **88**: 479; 14. (2,5) Dana and Onnes, *64P*, **29**: 1051, 1061; 26. (3) Dewar, *5*, **89**: 158; 13. (4) Eastman and Rodebush, *1*, **40**: 489; 18. (5) Eucken, *76*, **1912**: 141. (6) Eucken, *88*, **13**: 4; 16. (7) Eucken and Karwat, *7*, **112**: 467; 24. (8) Eucken and Schwers, *88*, **15**: 578; 13. (9) Griffiths and Griffiths, *5*, **90**: 557; 14.
(10) Günther, *8*, **51**: 828; 16. (11) Günther, *8*, **63**: 476; 20. (12) Heuse, *8*, **59**: 86; 19. (13) Keesom and Onnes, *64P*, **23**: 792; 14. (14) Keesom and Onnes, *64P*, **18**: 484; 15. *168*, No. **147a**. (15) Keesom and Onnes, *64P*, **18**: 1247; 16. *168*, No. **149a**. (16) Keesom and Onnes, *64P*, **20**: 1000; 18. *168*, No. **153a**. (17) Lange, *7*, **110**: 343; 24. (18) Maass and Waldbauer, *1*, **47**: 1; 25. (19) Nernst, *8*, **36**: 395; 11.
(20) Nernst and Lindemann, *9*, **17**: 817; 11. (21) Nernst and Schwers, *76*, **1914**: 355. (22) Onnes and Holst, *64P*, **17**: 760; 14. *168*, No. **142c**. (23) Pollitzer, *9*, **17**: 5; 11. (24) Pollitzer, *9*, **19**: 513; 13. (25) Rodebush, *1*, **44**: 1413; 23. (26) Russell, *63*, **13**: 59; 12. (27) Scheel and Heuse, *8*, **40**: 473; 13. (28) Simon, *8*, **68**: 241; 22. (29) Simon, *7*, **107**: 279; 23.
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HEAT CAPACITY OF SOLID AND LIQUID ELEMENTARY SUBSTANCES ABOVE 0°C*

LUIGI ROLLA AND GIORGIO PICCARDI

Where possible the information is presented in the form of the parameters of the equation $C_p = A + Bt + Ct^2 + \ldots$, where C_p is the atomic heat capacity in joules per gram atom per °C and t is the centigrade temperature.

Column two contains the value of the parameter A; column three, the value of 10^3B; column four, the temperature range covered by the data from which the equation was derived. When the letter M appears in column three, the value in column two is the mean heat capacity, C_m, over the temperature range given in column four. When a single temperature appears in column four, the value in column two is the heat capacity at that temperature. Values in bold-face type are "best" values as deduced from all of the information available. The accuracy of these values is difficult to estimate, but, in general, it may be stated that specific heat data on metals are rarely accurate to better than 1%, an uncertainty of several % being not unusual.

In cases where no "best" values are given, the available information is discordant, or lacks confirmation. In many cases information of this character is indicated by literature reference only.

L'information est présentée partout où cela est possible sous la forme des paramètres de l'équation $C_p = A + Bt + Ct^2 + \ldots$, où C_p est la capacité calorifique atomique exprimée en joules par atome gramme et par °C et t est la température centigrade.

La deuxième colonne contient la valeur du paramètre A; la troisième colonne, la valeur de 10^3B; la quatrième colonne, l'intervalle de température comportant les données à partir desquelles on a déduit l'équation. Lorsque la lettre M se trouve dans la troisième colonne, la valeur dans la deuxième colonne, représente la capacité calorifique moyenne C_m, pour l'intervalle de température donné dans la quatrième colonne. Lorsqu'il n'y a qu'une seule température dans la quatrième colonne, la valeur dans la deuxième colonne est la capacité calorifique à cette température. Les valeurs en caractères gras sont les "meilleures" valeurs, telles qu'on les a déduites de toute l'information disponible. La précision de ces valeurs est difficile à estimer, mais, en général il peut être établi que les données de chaleur spécifique se rapportant aux métaux sont rarement d'une précision supérieure à un pour cent, une incertitude de plusieurs pour cent n'étant pas rare.

Dans les cas ou les "meilleures" valeurs ne sont pas données, l'information disponible est discordante, ou a besoin de confirmation. Dans plusieurs cas l'information présentant ce caractère n'est indiquée que par une référence bibliographique.

Wo möglich ist die Angabe durch die Parameter der Gleichung $C_p = A + Bt + Ct^2 + \ldots$, gegeben. Hier bedeutet C_p den Atomwärmeinhalt in Joule pro Grammatom und pro °C, und t ist die Centigrad Temperatur.

Kolonne zwei enthält die Werte des Parameters A, Kolonne drei, von 10^3B; Kolonne vier den Temperaturbereich aus welchem die Daten bei der Ableitung der Gleichung herangezogen worden sind. Erscheint der Buchstabe M in der Kolonne drei, dann ist der Wert in der Kolonne zwei der mittlere Wärmeinhalt C_m in dem Temperaturbereich, welcher in der Kolonne vier angegeben ist. Erscheint in der Kolonne vier eine einzelne Temperaturangabe, so ist der in der Kolonne zwei angegebene Wärmeinhalt für diese Temperatur giltig. Zahlen in hervorgehobener Schrift stellen die "besten" dar, die sich aus allen zur Verfügung stehenden Werten ableiten liessen. Die Genauigkeit solcher Werte ist schwer zu schätzen, man kann jedoch im allgemeinen feststellen, dass die spezifischen Wärmen der Metalle selten genauer als auf 1% bekannt sind und Unsicherheiten bis auf einige Prozente kommen nicht selten vor.

In Fällen wo kein "beste" Werte angegeben sind, werden die vorliegenden Ergebnisse widersprechend sein, oder es fehlen Bestätigungen. In vielen Fällen sind Ergebnisse dieser Art nur durch die Literaturstellen angegeben.

Tutte le volte che è possibile, i valori sono riportati in forma di parametri dell'equazione: $C_p = A + Bt + Ct^2 + \ldots$, nella quale C_p è il calore atomico in joules per grammo atomo e per °C, e t è la temperatura in gradi centigradi.

La colonna 2 contiene i valori di A; la 3 i valori di 10^3B; la 4 l'intervallo di temperatura al quale si riferiscono i dati da cui è stata dedotta l'equazione. La lettera M nella colonna 3 indica che il valore della colonna 2 è il calore specifico medio, C_m, entro l'intervallo indicato nella colonna 4. Quando nella colonna 4 è indicata una sola temperatura, il valore riportato nella 2 rappresenta il calore specifico a quella temperatura. I valori in grassetto sono quelli "ottimi" quali si deducono da tutte le fonti disponibili. È difficile apprezzare l'esattezza di questi valori; in genere però si può dire che essa per i metalli raramente supera 1%, e che non sono infrequenti scarti superiori.

Quando non sono riportati valori "ottimi," significa che i dati disponibili non sono concordanti tra loro, oppure che non sono confermati. In molti casi, i dati di questo tipo sono riportati solo sotto forma di indicazioni bibliografiche.

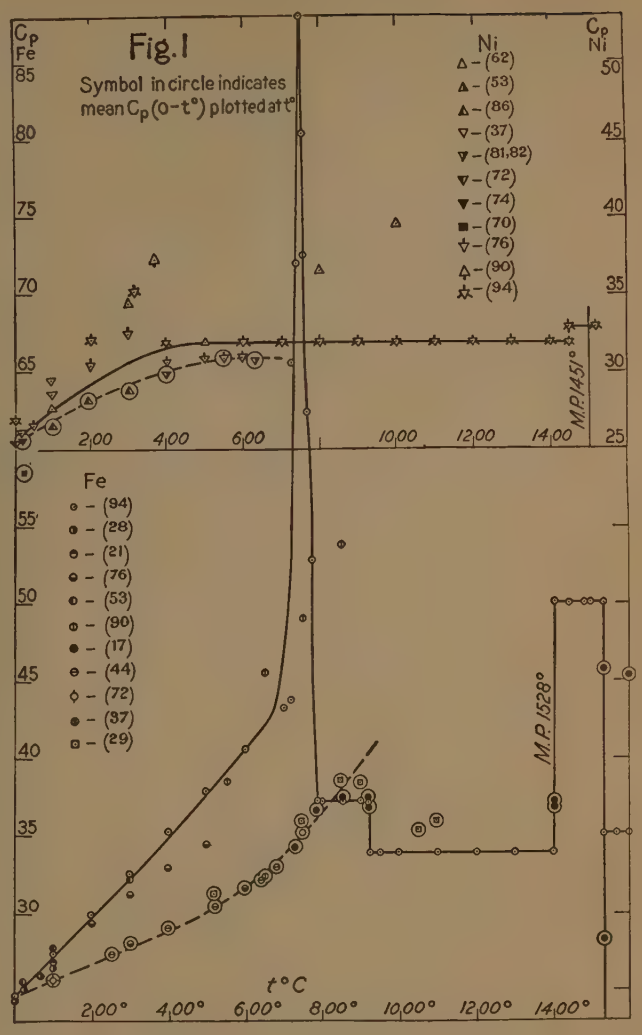
* For data below 0°, *v.* p. 84.

SOLIDS

	C_p, C_m or A	10^3B	t, or Δt, °C	Lit.
Al	**23.42**	**18.4**	0–100	(4, 9, 27, 28, 53, 56,
	26.0		150	76, 94)
	24.56	**9.83**	200–300	
	24.7	11	100–590	(19)
Ag	**25.11**	**6.03**	0–961	(19, 94)
As	24.2		28	(21)
	25.8	M	0–100	(92); *cf.* (7)
Au	**25.44**	**4.92**	0–400	(37, 72, 94)
Au.—(*Cont'd*)	25.4	5.6	20–850	(73)
	Higher temps.		to 1060	(83, 94)
B	1.005	M	−253 to −196	(16)
"Amorph."	3.22	M	−191 to −78	(40)
"Amorph."	7.60	M	−74 to 0	(40)
	9.90	33.1	400–900	(49.2)
	Higher temps.		to 230	(51, 87)
Ba	20	M	−253 to −196	(15, 16)
	39.1	M	−185 to 20	(70)

	C_p, C_m or A	10^3B	t, or Δt, °C	Lit.
Be	0.52	M	−253 to −196	(16)
	Higher temps.		to 300	(34, 58, 59)
Bi	**25.41**	**11.6**	25–200	(36, 37, 76, 94)
	Higher temps.		to 250	(83)
C	*v.* p. 94			
Caα	25.5	M	0–157	(6, 10)
	25.5	17.5	100–400	(19)
Caβ	27.7.	6.38	400–600	(19)
Cd	**25.76**	**11.0**	0–321	(14, 22, 23, 27, 37, 53, 69, 94)
Ce	26.3	M	0–100	(32)
	30.0	M	20–100	(33)
Co	15.65	55.4	−84 to −34	(76, 81)
	24.40	**18.2**	0–300	(12, 16, 24, 76)
	22.5	20	0–950	(94)
	27.3	7.2	1100–1470	(94); *cf.* (83)
Cr	**22.4**		0	(46, 70, 72, 76, 94)
	23.6		50	
	24.46		100	
	25.6		200	
	26.6		300	
	28.1		400	
	Higher temps.		to 1600	(83, 94)
Cs	29.0	15	0–28	(66)
Cu	**24.33**	**6.63**	0–500	(30, 53, 72, 76)
	Higher temps.		to 1000	(23, 43, 67, 83, 94, 95)
Fe	**24.51**	**24.6**	0–300	(17, 29, 90, 94; *cf.* 83)
	v. Fig. 1		to 1600	*cf.* (95)
Ge	24	M	0–440	(59)
Hg	*v.* p. 113			
I	27.84		1.8	(55)
In	27.4	M	0–100	(10)
Ir	26.1	M	0–100	(3, 85)
	Other values		−186 to 1400	(3, 85)
K	29.7s		13.6	(18)
	28.3	4.7	0–63	(66)
	30.7	M	0–22	(5)
	31.4	M	22–56	(5)
La	26	M	0–100	(32)
Li	23		0	(39, 42)
	31.7	M	0–100	(6)
Mg	**24.46**	**12.7**	0–300	(19, 72)
	25.1	10.9	100–615	(19)
	Higher temps.		to 600	(47, 76, 78)
Mn			0–1250	(42, 78, 94)
Mo	5.7		−223	(16)
	20.3	M	−188 to +20	(68)
	Other values		0–1500	(13, 78, 94)
Na	28.2		0	(39)
	27.1		0	(66)
	27.2*			(11, 26)
	27.6†			(26)
	28.6	M	0–20	(5)
	28.4		20.4	(18)
	27.1	45	0–97	(66)
	27.2	27	0–70	(11, 26, 27, 28)
	22.5	93	70–97	(11, 26, 27, 28)
Ni	**25.34**	**25.0**	0–200	(72, 76)
	v. Fig. 1		to 1400	(62, 76, 81, 82, 90, 94); *cf.* (79, 83, 95)

* Cooled slowly. † Quenched.



	C_p, C_m or A	10^3B	t, or Δt, °C	Lit.
Os	25		23	(65)
P, red	28.10	58.2	0–200	(92)
	24.64		9	(21)
White	23.01		9	(21)
Black	22.1		30–100	(45)
	26.6		50–100	(61)
Pb	**26.19**	**10.4**	0–327	(4, 27, 28, 37, 53, 81, 82)
Pd	8.5	M	−263 to −196	(16)
	23.1	M	−188 to +20	(68)
	21.9	M	−186 to −79	(4)
	25.3	M	−79 to +18	(4)
	25.98	9.04	0–1260	(85)
	26.17		18	(37)
	27.56		100	(37)
Pt	**25.71**	**5.45**	0–800	(22, 37, 74, 80, 81, 82, 84, 91, 94)
	25.89	**5.23**	300–1300	(91)

	C_p, C_m or A	10^3B	t, or Δt, °C	Lit.
Rb	28.3	M	20–35	(14)
	28.68	10.8	0–39	(66)
	32.5		50	(66)
Rh	25.0		10–100	(65)
Ru	26.0	M	0–100	(10)
S, rhomb.	23.0	M	0–35	(55, 92)
	23.6	M	0–95	(92)
Monocl.	24.0	M	0–38	(55, 92)
	24.3	M	0–52	(92)
Sb	25.13	74.5	0–300	(4, 68, 72, 76)
	Higher temps.		to 630	(38, 76, 94)
Se	25.6	M	22–62	(7)
Si	20.41	15.16*	0–700	(49)
Sn	26.53	17.3	0–100	(4, 22, 45.1, 45.2, 72, 76)
	Higher temps.		to 500	(83, 95)
Gray	24.5	M	8 to 13	(11.5)
White	26.7	M	13 to 18	(11.5)
Ta	21	M	−183 to −78	(77)
	24.3	M	−78 to +14	(77)
	25.1	M	14–100	(77)
	Higher temps.		to 1400	(63)
Te	25.58	3.7	−182 to +300	(82)
Th	26.8	M	0–100	(57)
Ti	16.5	M	−185 to +20	(60)
	28.6	15.6	0–300	(35)
Tl	26.6		+28	(21)
	25.3	M	−180 to +20	(68)
	24.6	M	−190 to −81.2	(71)
	26.0	M	−74 to ±0	(71)
	28.66	M	17–100	(64)
	27.9	M	20–100	(75)
U		M	0–100	(8, 64)
V	24.6	M	0–100	(46)
W	26.1	M	17–97	(13, 25)
	21.06	6.5	700–2500	(93) *q.v.* for additional Lit.; *cf.* (49.2)
Zn	25.10	11	0–300	(19, 27, 53, 72, 76)
	Higher temps.		to 400	(83)
Zr	25.5	M	0–100	(50, 89)

* $C = -9.15 \times 10^{-6}$.

C, Graphite (48, 73, 87)

t, °C	C_p	t, °C	C_p	t, °C	C_p
0	7.63	90	10.86	180	13.42
10	8.05	100	11.15	190	13.68
20	8.39	110	11.43	200	13.93
30	8.78	120	11.73	210	14.16
40	9.12	130	12.04	220	14.42
50	9.47	140	12.31	230	14.66
60	9.82	150	12.59	240	14.88
70	10.17	160	12.88	250	15.11
80	10.49	170	13.15		

The determinations by Magnus (49) between 10 and 830°C are represented by the equation,

$$C_p = 7.635 + 39.06 \times 10^{-3}t - 43.02 \times 10^{-6}t^2 + 29.57 \times 10^{-9}t^3 - 11.01 \times 10^{-12}t^4$$

According to Worthing's determinations (93), $C_p = 19.5 + 0.0035t$ in the range 900–2100°.

Acheson graphite (1)

t, °C	C_p	t, °C	C_p
26–76	8.29	35–900	16.3
26–280	9.83	40–925	16.3
25–490	11.3	48–1193	17.6
30–540	11.7	56–1450	19.6
30–750	14.5		

For natural graphites, coke, charcoal, etc., *v.* (7, 15, 16, 31, 41, 73, 80, 84, 85, 87, 93).

C, Diamond (48, 49, 56)

New determinations between 500 and 900° are given in (49.5)

t, °C	C_p	t, °C	C_p	t, °C	C_p
0	5.24	350	17.06	720	21.14
10	5.66	400	17.88	740	21.24
20	6.08	450	18.58	760	21.33
30	6.50	500	19.24	780	21.41
40	6.92	520	19.47	800	21.48
50	7.34	550	19.80	820	21.54
100	9.44	600	20.26	840	21.58
200	13.50	650	20.70	860	21.59
250	15.01	700	21.04	880	21.60
300	16.14				

LIQUIDS

Almost no reliable data exist on the specific heats of liquid elements. Some of the data found in the literature are presented below.

In the following table the quantity given is $\Delta = C_p$ (solid) $- C_p$ (liq.) at the melting point; joules per gram atom per deg. C.

Element	Δ	Lit.	Element	Δ	Lit.	Element	Δ	Lit.
Ag	2.9	(83)	Co	1.5	(94)	Pb	1.6	(36)
Al	2.5	(83, 94)		−8.6	(83)		0.47	(83)
			Cr	11	(83)	Sb	0.7	(94)
Au	1.8	(94)	Cu	1.8	(94)		−3.7	(83)
	8.2	(83)		4.2	(83)	Sn	3.1	(94)
Bi	0.2	(94)	Fe	15	(94)		2.3	(36)
	1.5	(36, 83)		−8.1	(83)		11.1	(83)
			Ni	−1.0	(94)	Zn	1.2	(94)
Cd	6.9	(94)		−9.2	(83)		−3.0	(36)
	0.4	(83)	Pb	1.2	(94)		−3.8	(83)

Br, $C_p = 35.8$, 1 to 45° (2).

Cs, $C_p = 33.6 - 0.019t$, M. P. to 100° (66).

Hg, *v.* p. 113.

K, $C_p = 23.2 + 0.109t$, M. P. to 100° (66).

Na, $C_p = 31.1$ at 100° (26, 28, 39); 31.8 at 98° (66); 33.4 at 98° (36). Decreases with rising temperature (26, 28).

Rb, $C_p = 32.9 - 0.0093t$, M. P. to 100° (66).

S, $C_p = 28.2 + 0.0215t$, 100 to 390° (45). For "viscous" S, *v.* (52).

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(For a key to the periodicals see end of volume)

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(60) Nordmeyer and Bernoulli, *88*, **9**: 175; 07. (61) Person, *6*, **21**: 295; 47. *8*, **74**: 409, 509; 49. (62) Pionchon, *34*, **102**: 675, 1454; 86. **103**: 1122; 86. **106**: 1344; 88. *6*, **11**: 33; 87. (63) Pirani, *88*, **14**: 1037; 12. (64) Regnault, *6*, **73**: 5; 1840. *8*, **51**: 44, 213; 1840. (65) Regnault, *6*, **63**: 5; 61. *13*, **121**: 237; 62. *3*, **23**: 103; 62. (66) Rengade, *34*, **156**: 1897; 13. **157**: 1356; 13. (67) Richards, *7*, **42**: 617; 03. (68) Richards and Jackson, *7*, **70**: 414; 10. (69) Rodebush, *1*, **45**: 1413; 12.
(70) Rolla, *36*, **44 I**: 646; 14. (71) Russell, *63*, **13**: 59; 12. (72) Schimpff, *7*, **71**: 257; 10. (73) Schläpfer and Debrunner, *37*, **7**: 31; 24. (74) Schlett, *Diss.*, Marburg, 1907. *8*, **26**: 201; 08. (75) Schmitz, *5*, **72**: 177; 03. (76) Schübel, *93*, **87**: 81; 14. (77) Siemens, *325*, **19**: 593; 09. (78) Stucken, *75*, **114 II**: 657; 05. (79) Sucksmith and Potter, *5*, **112**: 157; 26.
(80) Terres and Schaller, *397*, **65**: 818, 832; 22. (81) Tilden, *5*, **71**: 220; 03. *62*, **201**: 37; 03. (82) Tilden, *62*, **203**: 139; 04. (83) Umino, *159*, **15**: 597; 26. (84) Violle, *34*, **85**: 543; 77. *3*, **4**: 318; 77. (85) Violle, *34*, **87**: 981; 78. (86) Voigt, *8*, **49**: 709; 93. *188*, **1893**: 211. (87) Weber, *8*, **154**: 367, 553; 75. *3*, **49**: 161, 276; 75. (88) Weber, *242*, **23**: 209; 78. (89) Wedekind and Lewis, *13*, **371**: 382; 10.
(90) Weiss and Beck, *51*, **7**: 249; 08. (91) White, *2*, **12**: 436; 18. (92) Wigand, *8*, **22**: 64; 07. (93) Worthing, *2*, **12**: 199; 18. (94) Wust, Meuthen and Durrer, *Die temp. Wärmeinhaltskurven der technisch wichtigen Metalle*. Berlin, Selbstverlag Ver. deut. Ing., 1918. (95) Klinkhardt, *8*, **84**: 167; 27.

THE HEAT CAPACITY OF CHEMICAL COMPOUNDS IN THE CRYSTALLINE STATE

J. H. AWBERY

B-TABLE, STANDARD ARRANGEMENT (Vol. III, p. viii)

U = Transition temperature

Substance	t or Δt, °C	c_p, joule/g	± %	Lit.
H_2O	−250	0.151	2.5	(5, 125, 193, 194, 235, 236)
	−200	0.653	2	
	−150	1.030	1	
	−100	1.39	1	
	− 80	1.54	1	
	− 60	1.68	1	
	− 40	1.82	0.5	(5, 10, 70, 125, 193, 194, 195, 229, 235, 236, 244)
	− 20	1.94	0.5	
	0	2.06	0.5	
H_2O_2	−25	1.97	4	(161)
HCl, HBr, and HI, *v.* p. 86.				
SO_2	−185 to −103	0.96	5	(67)
H_2SO_4	−30	1.00	2	(230, 232)
	−20	1.10		
	−10	1.09		
	0	1.13		
$H_2S_2O_7$	35	0.64		(6)
NO	*v.* p. 86			
N_2O_5	−80 to 5	1.00	2	(261)
NH_3	−103 to −188	2.1	5	(67)
	v. also p. 86			
NH_4NO_3	−150	0.790	1	(25, 86, 322)
	−100	1.280	0.5	
	− 50	1.526		
	0	1.661	0.25	
	+ 50	1.735		
	100	1.790		
NH_4Cl	−250	0.041	1	(282); *cf.* (48, 67, 86, 137, 199)
	−225	0.267		
	−200	0.506		
	−150	0.824		
	−100	1.100	0.5	
	− 80	1.217		
	− 30U			
	− 20	1.460		
	0	1.496		
	+ 50	1.63	1	
$NH_4Cl\alpha$	185	1.96	3	(264)
$NH_4Cl\beta$	185	1.42	3	(264)
NH_4Br	−140	0.547	0.5	(86)
	−100	0.726	1	
	− 60	0.809		
	− 20	0.854		
	+ 20	0.879		
	60	0.888		
NH_4I	−150	0.406	1	(86)
	−100	0.431		
NH_4I.—(*Cont'd*)	0	0.464	0.5	
	+ 50	0.494		
$(NH_4)_2SO_4$	−200	0.335	5	(86, 125, 132, 137)
	−150	0.816		
	−100	1.184	2	
	0	1.409	0.5	
	+ 50	1.443	1	
PCl_3	33	0.85	2	(240, 241)
As_2O_3	−150	0.230	2	(240, 262)
	−100	0.318	1	
	0	0.489		
	40	0.509		
$AsCl_3$	56	0.74	2	(240)
Sb_2O_3	60	0.391	2	(199, 240)
Sb_2S_3	−150	0.226	1	(240, 262)
	−100	0.295		
	− 50	0.330		
	0	0.347		
	+ 50	0.360		
	100	0.370		
Bi_2O_3	50	0.238	2	(112, 240)
	100	0.248		
	200	0.258		
	300	0.264		
	400	0.268		
Bi_2S_3	50	0.251	2	(240)
CO	−260	0.239	1	(83)
	−240	0.705	0.25	
	−220	1.746		
	−213U			
	−212	1.792	0.25	
	−206	1.911		
CO_2	−260	0.046	8	(67, 83, 160)
	−250	0.153	6	
	−225	0.52	4	
	−200 to −75	$1.66\theta + 0.0048t$	3	
C_2N_2	−188 to 78	0.70	6	(68)
For other C-Compounds, *v.* p. 101				
SiO_2	*v.* p. 105			
$SiCl_4$	−200 to −80	$0.990 + 0.00278t$	1	(143)
SiC	−240	<0.001		
	−220	0.0092	8	
	−200	0.044	2	
	−100	0.341	1	(60, 106, 171, 198, 262, 313)
	0	0.60		
	+100	0.81	1	
	200	0.96		
	400	1.09	2	
	600	1.17		

Substance	t or Δt, °C	c_p, joule/g	± %	Lit.
SiC.—(*Cont'd*)	800	1.23		
	900	1.24		
TiO_2	0 to 500	$0.703 + 0.000456t$	3	(203, 240)
$TiCl_4$	−200	0.394	0.5	(143, 240)
	−175	0.353		
	−150	0.624		
	−100	0.717		
	− 25	0.739		
GeO_2	50	0.54	2	(203)
$ZrO_2.SiO_2$, Zircon	36	0.55	2	(137, 204)
ZrO_2	0 to 1500	$0.433 + 0.000208t$	2	(44, 202)
SnO_2	45	0.376	2	(137, 240)
$SnCl_2$	60	0.427	2	(240)
$SnCl_4$	−200	0.314	0.5	(143, 240,
	−150	0.428		241)
	−100	0.482		
	− 50	0.529		
SnS	56	0.351	2	(240)
SnS_2	54	0.50	2	(240)
PbO	−250	0.0313	1	(137, 170,
	−200	0.1012		198, 240,
	−150	0.139		262, 299)
	−100	0.166		
	− 50	0.188		
	0	0.202		
	+ 50	0.213		
	100	0.218		
	200	0.222		
PbO_2	−150	0.151	2	(215, 262)
	− 50	0.232		
	0	0.259		
	+ 50	0.272		
PbF_2	9	0.301	2	(271)
$PbCl_2$	−260	0.0238	3	(48, 78, 82,
	−240	0.0970	2	98, 147,
	−220	0.1568		169, 194,
	−200	0.1920	1	271)
	−150	0.2271	0.5	
	−100	0.2497		
	0	0.2718	0.2	
	+100	0.2848	0.5	
	200	0.2948		
	300	0.310	1	
	400	0.335	3	
$PbBr_2$	−150	0.107	10	(13, 78, 98,
	− 50	0.187	3	240, 271)
	0	0.210	1	
	+ 50	0.222		
	100	0.227		
	200	0.230		
	400	0.235		
PbI_2	−250	0.0706	1	(198)
	−225	0.1205		
	−200	0.1380	0.5	(13, 78, 138,
	−150	0.1531		169, 198,
	−100	0.1627		240, 271)
	0	0.1744		
	+100	0.183	1	
	200	0.197		
	250	0.204		
PbS	−220	0.118	5	(39, 76, 117,
	−200	0.144	2	132, 147,
	−150	0.176		199, 240,
	−100	0.194	1	255, 287,
	− 50	0.205		299)
	0	0.210		
	+100	0.214	2	
	200	0.217		
	400	0.227	4	
	450	0.233	6	
$PbSO_4$	45	0.351	3	(137, 240)
PbS_2O_3	58	0.384	2	(217)
$Pb(NO_3)_2$	45	0.481	1	(137, 199)
$2PbCl_2.NH_4Cl$	10	0.362	1	(48)
PbP_2O_7	55	0.343	2	(240)
$Pb_3As_2O_8$	55	0.305	2	(240)
$PbCO_3$	32	0.335	2	(137)
$PbSiO_3$	60	0.326	1	(274)
ThO_2	−150	0.128	1	(67, 202,
	−100	0.175		262)
	− 50	0.212		

Substance	t or Δt, °C	c_p, joule/g	± %	Lit.
ThO_2.—(*Cont'd*)	0	0.239		
	+ 50	0.246		
ThCl	30	1.70	3	(87)
$Th(SO_4)_2$	50	0.41	2	(202)
In_2O_3	50	0.338	2	(202)
TlCl	−250	0.056	2	(98, 236,
	−230	0.1280	0.5	262)
	−200	0.1677		
	−150	0.1931		
	−100	0.2047		
	0	0.2175		
	+100	0.227		
	200	0.233	1	
	400	0.242	2	
TlBr	390	0.220	2	(97)
$TlC_6H_2N_3O_7$				
picrate (red)	10	0.573	1	(48)
(yellow)	10	0.560	1	(48)
ZnO	−200	0.155	3	(64, 170,
	−100	0.35		173, 240)
	0	0.477	1	
	+100	0.541		
	200	0.577		
	400	0.62	2	
	600	0.64		
	800	0.66		
	1000	0.68		
	1200	0.69		
$ZnCl_2$	60	0.57	2	(240)
ZnS, Sphalerite	−260	0.0088	5	(106)
	−240	0.0790	0.5	
	−220	0.155		
	−200	0.202	2	
ZnS	−260	0.029	3	(106, 117,
	−240	0.253	0.5	132, 137,
	−220	0.386		147, 199,
	−200	0.430	1	240)
	−175	0.453		
	−150	0.464		
	−100	0.477	2	
	0	0.486		
	+100	0.493		
	200	0.502		
	400	0.510		
$ZnSO_4$	50	0.73	2	(216)
$ZnSO_4.H_2O$	9	0.81	2	(256)
$ZnSO_4.6H_2O$	9	1.25	2	(256)
$ZnSO_4.7H_2O$	−250	0.063	3	(58, 88, 125,
	−200	0.409	1	137, 216,
	−150	0.738	0.5	235, 236,
	−100	0.960		256, 270,
	0	1.346	0.25	271)
	+ 50	1.437	0.5	
$Zn(NO_3)_2.6H_2O$	30	1.33	1	(254)
$ZnCO_3$	0 to 260	$0.593 + 0.0_3193t$	3	(147)
$Zn(C_2H_3O_2)_2$	45	1.13	2	(114)
$Zn(C_2H_3O_2)_2.3H_2O$	85	1.71	2	(114)
$2CdCl_2.5H_2O$	−200 to 20	$1.019 + 0.00350t$	4	(277)
CdS	−150	0.227	0.5	(262)
	−100	0.301		
	0	0.369		
	+ 50	0.386		
$3CdSO_4.8H_2O$	−200	0.259	5	(58, 59, 124,
	−150	0.481	10	125, 277)
	−100	0.636		
	− 50	0.749	4	
	0	0.816	2	
	+ 20	0.836	0.5	
$Cd(NO_3)_2.4H_2O$	40	1.09	1	(254)
HgO	−250	0.0347	1	(106, 137,
	−225	0.0820	0.5	240, 262)
	−200	0.1087		
	−100	0.165		
	0	0.203		
	+ 50	0.218		
HgCl	−250	0.0556	0.5	(48, 82, 169,
	−200	0.1430		235, 236,
	−150	0.1740	0.25	240)
	−100	0.1892		
	0	0.2087	0.25	
	50	0.2141		

Substance	t or Δt, °C	c_p, joule/g	± %	Lit.
$HgCl_2$	−150	0.203	1	(86, 137,
	−100	0.235	0.5	240)
	− 50	0.257		
	0	0.268		
	+100	0.280		
$HgBr_2$	100	0.217	3	(109)
HgI	−120 to +100	$0.1498 + 0.0465t$	2	(86, 240)
HgI_2 (red)	−150	0.147	1	(13, 86, 108,
	−100	0.159	0.5	109, 240)
	0	0.169		
	+ 50	0.173		
	100	0.173		
(yellow)	206	0.167	10	(108, 109)
HgS	−150	0.135	1	(137, 240,
	−100	0.178	0.5	262)
	− 50	0.200		
	0	0.2116	0.25	
	+ 50	0.2175		
	100	0.2187		
Hg_2SO_4	−250	0.0452	1	(58, 235,
	−200	0.1087	0.5	236, 270,
	−150	0.1713	0.25	271)
	−100	0.2032		
	0	0.2580		
	+ 50	0.2844	0.25	
$Hg(CN)_2$	29	0.42	3	(137)
CuO	−200	0.144	0.25	(137, 169,
	−100	0.376		240, 262)
	0	0.523		
	+100	0.602		
	200	0.648		
	400	0.669		
	600	0.677		
Cu_2O	0	0.460	1	(137, 169)
	100	0.485		
	200	0.506		
	300	0.523		
	400	0.535		
$CuCl_2$	58	0.58	2	(240)
CuI	−260	0.0226	0.25	(86, 240,
	−230	0.1217		282)
	−200	0.1907		
	−150	0.2350		
	−100	0.2543		
	− 50	0.2668		
	0	0.2752		
	+ 50	0.2810		
CuS	−150	0.32	6	(39, 262)
	− 75	0.43	4	
	0	0.54	2	
	+100	0.63		
	200	0.72	4	
	300	0.67	5	
	400	0.61	6	
	500	0.56	6	
	600	0.52	5	
	800	0.48	5	
Cu_2S	0 to 100	$0.449 + 0.00110t$	2	(24, 240)
	104U			
	190	0.61	2	(24)
$CuSO_4$	−150	0.328	0.5	(86, 125,
	− 50	0.537		195, 216,
	0	0.618		270, 279)
	+ 50	0.694		
$CuSO_4.H_2O$	−150	0.396	0.5	(86, 195, 270,
	− 50	0.617		279)
	0	0.719		
	+ 50	0.798		
$CuSO_4.3H_2O$	9	0.956		(270)
$CuSO_4.5H_2O$	−150	0.648	2	(86, 125,
	−100	0.790		137, 240,
	− 50	0.924		270, 279,
	0	1.058		282)
	+ 50	1.200		
Cu_2Se	60	0.437	2	(24)
	110U			
	200	0.437	2	
$CuSO_4.(NH_4)_2SO_4.$-$6H_2O$	−150	0.85	2	(125)
	− 75	0.97		
	0	1.07		

Substance	t or Δt, °C	c_p, joule/g	± %	Lit.
$2CuO.CO_2.H_2O$, Malachite	57	0.74	2	(204)
$CuPbSbS_3$, Bournonite	50	0.31	5	(278)
AgCl	−260	0.037	6	(48, 67, 78,
	−240	0.143	2	82, 86, 98,
	−220	0.231	0.5	169, 194,
	−200	0.2655		198, 240)
	−100	0.331	0.25	
	− 50	0.351		
	0	0.355		
	+ 50	0.379		
	100	0.3885	0.5	
	200	0.408		
	300	0.414	1	
	400	0.421		
	500	0.423		
AgBr	−100	0.261	2	(67, 98, 240)
	− 50	0.265		
	0	0.291	1	
	+100	0.307		
	200	0.312	2	
	400	0.318		
AgI	−260	0.043	4	(25, 67, 86,
	−240	0.102	2	138, 169,
	−220	0.140	1	193, 194,
	−200	0.1706		198, 240)
	−150	0.2028	0.5	
	−100	0.2120		
	− 50	0.2175	0.25	
	0	0.2292		
	+100	0.248	1	
Ag_2S	−150	0.196	1	(24, 255,
	−100	0.251		278)
	0	0.301		
	+ 50	0.313		
	100	0.318		
	150	0.35		
Ag_2Se	37 to 187	0.29	3	(24)
$AgNO_3$	50	0.61	4	(109, 240)
	160U			
	178	0.65		(108, 109)
	192	0.82	4	(98)
Ag_3AsS_3, Proustite	50	0.34	3	(278)
Ag_3SbS_3, Pyrargyrite	50	0.32	3	(278)
AgCN	−150 to 20	$0.586 + 0.00230t$	2	(68)
AgCNO	40	0.52	2	(211)
$(AgCNO)_3$	40	0.410	2	(211)
$AgI.PbI_2$	50 to 250	$0.182 + 0.000114t$	2	(25)
AuI	−100	0.148	2	(180)
	− 50	0.157	1	
	0	0.169		
	+ 50	0.181		
MnO	58	0.66	2	(137)
MnO_2	−150	0.355	1	(137, 262)
	−100	0.480	0.5	
	− 50	0.573		
	0	0.636		
	+ 50	0.682		
	100	0.703	1	
Mn_2O_3	58	0.68	2	(204)
$Mn_2O_3.3H_2O$	38	0.74	2	(137)
MnS	60	0.58	2	(278)
$MnSO_4$	61	0.76	2	(216)
$MnSO_4.5H_2O$	32	1.35	2	(137)
$Mn(NO_3)_2.6H_2O$	47	1.56	2	(254)
Fe_2O_3	−180	0.171	2	(50, 220,
	−100	0.410		240, 262)
	0	0.619		
	+100	0.76		
	200	0.85		
	300	0.94		
	350	0.98		
	360	U		
	370	1.06		
	400	1.10		
	500	1.23		
	600	1.36		
	700	1.49		

Substance	t or Δt, °C	c_p, joule/g	± %	Lit.
$2Fe_2O_3.3H_2O$, Limonite	60	0.94	2	(132)
Fe_3O_4	−200	0.14	10	(220, 240,
	−100	0.45	5	314)
	0	0.63		
	+100	0.75		
	200	0.85		
	300	0.93		
	400	1.00		
	500	1.07		
	550	1.11		
FeS	0 to 700	$0.567 + 0.00065t$	2	(39, 240)
FeS_2	−280	0.0042	3	(85, 86, 117,
	−225	0.0197	2	132, 137,
	−200	0.075		138, 199,
	−150	0.222	1	240, 299)
	−100	0.352	0.5	
	− 50	0.483		
	0	0.493		
	+ 50	0.535		
	100	0.569	1	
	150	0.615	1.5	
Fe_7S_8, Magnetic pyrites	0	0.594	2	(117, 147,
	100	0.657		199)
	200	0.77	3	
	300	0.96		
	350	1.11	4	
$FeSO_4$	45	0.70	3	(202)
$FeSO_4.4H_2O$	9	1.19	2	(256)
$FeSO_4.7H_2O$	−150	0.67	2	(125, 137,
	−100	0.90		256)
	− 50	1.12	1	
	0	1.36		
	+ 10	1.41		
FeAsS	55	0.47	10	(204, 278)
$FeAs_2$	50	0.36	3	(278)
$FeCO_3$	54	0.81	2	(240)
$Fe_2(SiO_3)_2$	59	0.80	2	(305)
$FeCuS_2$, Chalcopyrite	48	0.54	2	(132, 137,
				204)
$FeCu_2S_3$	48	0.49	2	(278)
$CoSO_4.7H_2O$	48	1.43	2	(137)
$Co(NO_3)_2.6H_2O$	32	1.56	0.5	(254)
CoAsS, Cobaltite	58	0.41	2	(204, 278)
NiS	−100	0.372	3	(298)
	0	0.485	2	
	+100	0.537		
	200	0.577		
	225	0.583		
$NiSO_4$	58	0.90	2	(216)
$NiSO_4.6H_2O$	35	1.31	2	(137)
$Ni(NO_3)_2.6H_2O$	80	1.98	0.5	(254)
$Ni(CO)_4$	−78 to −188	0.69	3	(68)
FeCoNiAs$_6$	50	0.35	3	(278)
Cr_2O_3	−200	0.111	2	(137, 240,
	−100	0.414	1	262)
	0	0.703		
	+ 50	0.790		
$Cr_2(SO_4)_3$	50	0.72	2	(202)
$Cr_2(SO_4)_3.5H_2O$	50	0.836	2	(202)
$PbCrO_4$	35	0.38	2	(137)
MoO_3	54	0.56	2	(240)
WO_3	−150	0.15	2	(240, 262)
	−100	0.222	1	
	0	0.311		
	+ 50	0.348		
$3MnWO_4.2FeWO_4$	0 to 300	$0.41 + 0.00007t$	3	(147)
U_3O_8	−150	0.164	1	(262)
	−100	0.206		
	0	0.281		
	+ 50	0.314		
Cb_2O_5	50 to 450	$0.423 + 0.00064t$	2	(201)
B_2O_3 (vitreous)	−250 to 200	$0.805 + 0.0023\epsilon t$	3	(86, 240,
				263)
PbB_2O_4	57	0.378	2	(240)
PbB_4O_7	57	0.47	2	(240)
$PbMoO_4$	15	0.42	2	(55.5)
$PbWO_4$	15	0.322	2	(55.5)

Substance	t or Δt, °C	c_p, joule/g	± %	Lit.
BN	200	1.46	2	(172)
	400	1.80		
	600	2.06	4	
	800	2.28		
	900	2.36		
Al_2O_3, Corundum, sapphire, etc.	−200	0.069	1	(60, 85, 132,
	−150	0.225		202, 220,
	−100	0.415		234, 240
	− 50	0.598		262, 311)
	0	0.73		
	+ 50	0.83	3	
	100	0.89	5	
	200	0.97		
	400	1.07		
	600	1.12		
	800	1.15		
	1000	1.17		
$Al(OH)_3$	−200	0.146	1	(132, 202,
	−100	0.433	1	234, 240,
	0	0.740	0.5	262, 311)
	+ 50	0.845		
	100	0.899		
	200	0.962	1	
	300	0.995		
	400	1.012	2	
	600	1.029		
	800	1.034	3	
	900	1.096	4	
	1000	1.150	6	
	1100	1.255	6	
AlF_3	35	0.96	2	(22)
$2AlF_3.7H_2O$	35	1.43	2	(22)
$AlCl_3$ (α)	93	1.96	2	(264)
(β)	0	0.82	2	(22, 264)
	100	1.52		
$AlCl_3.6H_2O$	35	1.31	2	(22, 290)
$AlCl_3.6NH_3$	− 4	1.67	2	(22)
$Al_2(SO_4)_3$	50	0.77	2	(202)
$Al_2(SO_4)_3.17H_2O$	34	1.48	1	(22)
$Al_2C_{12}O_{12}.18H_2O$, Mellite	52	1.39	2	(16)
Al_2SiO_5, *v.* p. 101.				
$2(AlF)O.SiO_2$, Topaz	52	0.86	1	(132, 147)
Sc_2O_3	−150 to 40	$0.701 + 0.00275t$	1	(202, 262)
Y_2O_3	57	0.468	1	(202)
La_2O_3	50	0.314	2	(202)
$La_2(MoO_4)_3$	15	0.48	2	(55.5)
CeO_2	−150	0.177	0.5	(202, 262)
	−100	0.251		
	− 50	0.309		
	0	0.364		
	+ 50	0.397		
$CeSO_4$	50	0.49	3	(202)
$CeSO_4.5H_2O$	50	0.84	3	(202)
$Ce_2(MoO_4)_3$	15	0.53	2	(55.5)
Ga_2O_3	50	0.44	2	(202)
Er_2O_3	50	0.272	2	(202)
Yb_2O_3	50	0.272	2	(202)
BeO	−200	0.029	3	(106)
	−190	0.043		
	−180	0.065		
	+ 50	1.09	2	(172, 202)
	100	1.25		
	200	1.47		
	400	1.76		
	600	1.93		(202)
	800	2.04		
	900	2.08		
$BeSO_4$	50	0.83	2	(202)
Al_2BeO_4, Chrysoberyl	50	0.84	3	(202)
$Y_2(MoO_4)_3$	15	0.87	2	(55.5)
$3BeO.Al_2O_3.6SiO_2$, Beryl	57	0.84	2	(132, 204)
MgO	−240	0.0027	3	(106)
	−220	0.0146		
	−200	0.066	2	
	−180	0.157		
	−150	0.314		

Substance	t or Δt, °C	c_p, joule/g	± %	Lit.
MgO.—(*Cont'd*)...	−100	0.54		(170, 220,
	− 50	0.74		240, 262)
	0	0.874		
	+ 50	0.97	1	
	100	1.02		
	200	1.09		
	400	1.16		
	600	1.22		
	800	1.28		
	1000	1.35	3	
	1500	1.49	5	(311)
	2000	1.62		
	2500	1.75	10	
$MgO.H_2O$, Brucite..	35	1.30	2	(137)
$MgCl_2$.....	48	0.81	1	(137, 240)
$MgCl_2.6H_2O$.....	44	1.58	1	(254)
$MgSO_4$.....	61	0.93	1	(216, 240)
$MgSO_4.H_2O$.....	9	1.00	2	(256)
$MgSO_4.6H_2O$.....	9	1.46	2	(256)
$MgSO_4.7H_2O$.....	12	1.51	1	(137, 256)
$Mg(NO_3)_2.6H_2O$....	55	3.71	1	(254)
$MgCO_3$.....	25	0.838	0.5	(184)
$Mg_3Si_4O_{11}.H_2O$, Talc.....	57	0.87	2	(204)
$6MgO.MgCl_2.8B_2O_3$, Boracite (hexahedral).....	−50 to 350	$0.753 + 0.002543t$	4	(140)
(dodecahedral)...	50	0.90	2	(140)
	100	1.00		
	200	1.22		
	250	1.37	5	
	265U			
	300	1.69		
CaO.....	−240	0.011	7	(86, 138, 142,
	−220	0.053	6	170, 195,
	−200	0.142	2	198, 220,
	−150	0.368		311)
	−100	0.54		
	− 50	0.66		
	0	0.74	1	
	+100	0.824		
	200	0.857		
	400	0.882	2	
	600	0.91		
	800	0.92	4	
	1000	0.94		
	1200	0.95		
CaH_2.....	−210	0.141	3	(106)
	−200	0.195		
	−180	0.302		
$Ca(OH)_2$.....	−250	0.029	3	(86, 138,
	−200	0.205	2	198)
	−150	0.510	1	
	−100	0.765	0.5	
	− 50	0.949		
	0	1.087		
	+ 50	1.204		
CaF_2.....	−250	0.0117	4	(85, 132,
	−200	0.218	3	137, 138,
	−150	0.470	0.5	199, 240)
	−100	0.640	0.25	
	− 50	0.803		
	0	0.854		
	+ 40	0.887		
	80	0.907		
$CaCl_2$.....	61	0.686	2	(240)
$CaCl_2.6H_2O$.....	−150	0.91	5	(67, 228)
	− 75	1.18	4	
	0	1.34		
$CaSO_3.2H_2O$.....	9	1.14	1	(34)
$CaSO_4$.....	0 to 400	$0.7084 + 0.000609t$	1 to 3	(137, 147, 240, 312)
$CaSO_4.2H_2O$.....	[illegible]	1.11	1	(132, 137, 199, 312)
$Ca(PO_3)_2$.....	−260	0.00530	0.5	(106)
	−240	0.01212		
	−220	0.0432		
	−200	0.1018		
	−100	0.563	10	(106, 240)
	0	0.795	6	
	+ 50	0.828	2	

Substance	t or Δt, °C	c_p, joule/g	± %	Lit.
CaC_2.....	20–325	0.92		(260)
	20–500	1.00		
	20–725	1.15		
$CaCO_3$, Aragonite..	−250	0.0100	2	(195)
	−200	0.188	1	
	−150	0.410	7	(137, 195)
	−100	0.586		
	− 50	0.698		
	0	0.787	2	(48, 106, 132,
	+ 50	0.853		137, 147,
	100	0.886		199, 204,
	200	0.941		240)
	300	0.979		
$CaCO_3$, Spar.....	−250	0.0088	5	(48, 49, 106,
	−225	0.0611	3	132, 138,
	−200	0.301	2	147, 170,
	−150	0.452	1	204, 240)
	−100	0.590		
	0	0.763	0.5	
	+100	0.870		
	200	0.962	1	
	400	1.129		
$CaCO_3$, Marble....	−250	0.042	2	(113, 198,
	−200	0.280	1	222, 240,
	−100	0.539		297, 312)
	− 50	0.790		
	0	0.851		
	+100	0.897		
	200	0.918		
	300	0.928		
$Ca(HCO_2)_2$, Formate.....	0 to 100	$0.994 + 0.00046t$	2	(114)
$CaSiO_3$, Wollastonite.....	0	0.72	1	(204, 316,
	100	0.816		318)
	200	0.890	1	
	400	0.982		
	800	1.08		
	1200	1.12		
$CaSiO_3$, Pseudo-wollastonite.....	100 to 1300	Less by 0.006 than Wollastonite		(316, 318)
$CaMoO_4$.....	15	0.69	2	(55.5)
$CaWO_4$.....	15	0.435	2	(55.5)
$CaO.Al_2O_3(SiO_2)_2$, Anorthite.....	0	0.73	2	(204, 318)
	100	0.86		
	200	0.95		
	400	1.05		
	600	1.11		
	800	1.16		
	1000	1.20		
CaO.MgO.....	25	0.879	0.5	(184)
$CaMg(CO_3)_2$.....	46	0.91	2	(137, 305)
$CaMg(SiO_3)_2$, Diopside.....	50	0.81	0.5	(316, 317,
	100	0.87		318)
	200	0.95		
	300	1.02	1	
	400	1.07		
	600	1.12		
	800	1.17		
	1000	1.19		
	1200	1.20		
	1300	1.20		
$SrCl_2$.....	58	0.50	2	(240)
$SrSO_4$.....	48	0.60	2	(137, 240)
$Sr(NO_3)_2$.....	32	0.76	2	(137)
$SrCO_3$.....	54	0.61	2	(240)
$SrMoO_4$.....	15	0.62	2	(55.5)
$BaCl_2$.....	0 to 100	$0.3567 + 0.000385t$	1	(137, 240, 270, 271)
$BaCl_2.H_2O$.....	9	0.52	2	(270, 271)
$BaCl_2.2H_2O$.....	0 to 50	$0.5872 + 0.003287t$	2	(137, 270, 271)
$Ba(ClO_3)_2.H_2O$.....	[illegible]	0.66	2	(137)
$BaSO_4$.....	0 to 1000	$0.4650 + 0.000140t$	2 to 4	(132, 137, 142, 147, 199, 240)
BaS_2O_3.....	58	0.68	[illegible]	(217)
$Ba(NO_3)_2$.....	47	0.62	2	(137, 240)

Substance	t or Δt, °C	c_p, joule/g	± %	Lit.
$BaCO_3$	0	0.418	2	(132, 199, 240)
	100	0.460		
	200	0.485	2	
	400	0.514		
	600	0.539	3	
	800	0.544		
$BaCO_3$, Witherite	800	0.581	3	(142)
	900	0.657		
	1000	0.673		
$Ba(CHO_2)_2$, Formate	0 to 120	$0.572 + 0.0006t$	1 to 2	(114)
$BaMoO_4$	15	0.47	2	(55.5)
LiH	−200	0.341	0.5	(107)
	−180	0.667		
	−160	1.18	2	
	− 80	3.06		
	0	4.10	0.5	
	+ 50	4.48		
LiOH	−210	0.079	5	(107)
	−200	0.119	3	
	−190	0.164	1	
	−180	0.224		
	−170	0.295		
	−100	0.88	5	
	0	1.37	1	
	+ 50	1.49		
LiF	10	1.56	1	(49)
LiCl	55	1.18	2	(245)
$Li_2S_2O_3$	58	0.385	2	(217)
$LiNO_3$	210	1.62	2	(98)
$Li_2O.Al_2O_3.4SiO_2$, Spodumene	60	0.90	3	(274)
$Li_2O.Al_2O_3.8SiO_2$, Petalite	58	0.85	2	(204)
NaF	−150	0.675	2	(49, 138)
	−100	0.886		
	− 50	1.013	0.25	
	0	1.080		
	+100	1.167		
NaCl	−250	0.021	10	(49, 67, 138,
	−200	0.466	1	146, 170,
	−150	0.657	0.5	194, 196,
	−100	0.736		197, 240,
	0	0.853		262)
	+100	0.908	1	
	200	0.924	2	
	400	0.96	4	
	500	0.97		
	600	0.99		
NaBr	−150	0.408	0.5	(49, 138, 170,
	−100	0.450		240, 272)
	0	0.492		
	+100	0.518	1	
	200	0.527		
NaI	−150	0.302	1	(49, 138, 240,
	−100	0.324		272)
	0	0.347		
	+ 50	0.355		
Na_2SO_4	−200	0.315	0.5	(86, 125, 240,
	−150	0.503		272)
	−100	0.654		
	− 50	0.770		
	0	0.846		
	+100	0.919		
$Na_2S_2O_3$	9	0.92	1	(217, 271)
$Na_2S_2O_3.5H_2O$	21	1.45	3	(271, 303)
$NaNO_3$	−150	0.627	0.5	(86, 98, 240,
	−100	0.807		272)
	− 50	0.937		
	0	1.035		
	+50	1.129		
	100	1.23	1	
	200	1.38	2	
	250	1.50	4	
$NaPO_3$	30	0.91	2	(137)
$Na_4P_2O_7$	50	0.95	2	(240)
$Na_2HPO_4.7H_2O$	−200	0.50	2	(193, 195)
	−100	1.03	1	
	0	1.47		
	+ 50	1.70		

Substance	t or Δt, °C	c_p, joule/g	± %	Lit.
$Na_2HPO_4.12H_2O$	−200	0.50	2	(193, 194,
	−100	1.12	1	195, 225)
	0	1.69		
	+ 50	1.94		
Na_2CO_3	45	1.07	2	(137, 240)
$NaHCO_3$, Formate	46	1.28	1	(114, 212)
$NaC_2H_3O_2$, Acetate	38	1.42	4	(96, 212)
$NaC_2H_3O_2.3H_2O$	0	1.44	5	(96)
	10	1.72		
	20	1.98		
	40	2.52		
NaCNO	40	0.84	2	(211)
$(NaCNO)_3$	40	0.69	2	(211)
$Na_2SO_4.CuSO_4.6H_2O$	−150	0.437	2	(125)
	−100	0.611	1	
	0	0.824	0.5	
$Na_2B_2O_4$	57	1.06	2	(240)
$Na_2B_4O_7$	45	0.98	2	(137, 240)
$Na_2B_4O_7.10H_2O$, Borax	35	1.61	3	(137)
$3NaF.AlF_3$, Cryolite	43	1.054	0.5	(22, 132, 137, 204)
$Na_2O.Al_2O_3.6SiO_2$, Albite	− 50	0.640	2	(204, 318)
	0	0.745		
	+100	0.887		
	200	0.991		
	300	1.058		
	400	1.096		
	600	1.154		
	800	1.200		
	1000	1.240		
$3(NaAlSi_3O_8) + 2(CaAl_2Si_2O_8)$, Andesine	0	0.75	5	(204, 318)
	100	0.86		
	200	0.95		
	400	1.08	2	
	600	1.13		
	800	1.17		
	1000	1.19		
K_2O_2	200 to 700	$0.833 + 0.000116t$	1	(170)
KF	−150	0.602	1	(49, 138)
	−100	0.727	0.5	
	− 50	0.799		
	0	0.831		
	+ 50	0.853		
KCl	−250	0.069	1	(49, 137, 138,
	−200	0.448	0.5	146, 170,
	−150	0.588		194, 196,
	−100	0.634		197, 198,
	− 50	0.664		240, 262)
	0	0.680		
	+100	0.703		
	200	0.721	1	
	400	0.749	2	
$KClO_3$	−150	0.500	2	(86, 98, 137,
	−100	0.644	1	240)
	0	0.799		
	+ 50	0.857		
	100	0.970	1	
	200	1.238	2	
	225	1.355	3	
$KClO_4$	30	0.79	3	(137)
KBr	−200	0.3254	0.5	(49, 86, 138,
	−100	0.4027		170, 194,
	0	0.435		240)
	+100	0.452		
	200	0.460		
	300	0.463		
KI	−140 to 80	$0.3124 + 0.000230t$	1	(49, 138, 195, 240)
K_2SO_4	−150	0.473	1	(86, 125, 137,
	−100	0.577		240)
	0	0.736		
	+100	0.799		
$K_2S_2O_8$	60	0.82	2	(217)
$KHSO_4$	35	1.02	2	(137)
KNO_3	−150	0.579	0.5	(86, 98, 137,
	−100	0.740		240)

Substance	t or Δt, °C	c_p, joule/g	± %	Lit.
KNO_3.—(*Cont'd*)...	0	0.895		
	+100	1.004	1	
	200	1.117		
	300	1.22	2	
$K_4P_2O_7$.....	58	0.80	2	(240)
KH_2PO_4.....	33	0.87	3	(137)
$KAsO_2$.....	58	0.65	2	(240)
KH_2AsO_4.....	31	0.73	2	(137)
K_2CO_3.....	47	0.88	1	(137, 240)
$K_2C_2O_4.H_2O$.....	−100	0.70	1.5	(90, 137)
	− 60	0.85		
	− 20	0.93		
	+ 20	0.97		
$KC_2H_3O_2$.....	20	1.14	2	(114)
	40	1.74		
	60	2.20		
	80	2.63		
	100	2.90		
$KH_3C_4O_8.2H_2O$.....	35	1.18	2	(137)
$K(d\text{-}C_4H_5O_6)$.....	10	0.97	1	(48)
$K(dl\text{-}C_4H_5O_6)$.....	10	0.98	1	(48)
$K_2C_4H_4O_6$.....	35	1.07	2	(137)
K_2SnCl_6.....	35	0.56	2	(137)
K_2ZnCl_4.....	32	0.64	2	(137)
$K_2SO_4.ZnSO_4.6H_2O$.	−150	0.49	2	(125)
	−100	0.65		
	0	0.81		
$K_2Zn(CN)_4$.....	30	1.01	2	(137)
$K_2CuCl_4.2H_2O$.....	35	0.82	2	(137)
K_2PtCl_6.....	30	0.47	2	(137)
$K_3Fe(CN)_6$.....	26	0.97	2	(137)
$K_4Fe(CN)_6$.....	−200	0.397	3	(193, 194,
	−150	0.544		195, 270,
	−100	0.694	2	271)
	0	0.878	1	
	+ 50	0.941		
$K_4Fe(CN)_6.3H_2O$...	−200	0.464	3	(193, 194,
	−150	0.757	1	195, 270,
	−100	0.937	0.5	271)
	0	1.118		
	+ 50	1.192		
$K_2SO_4.NiSO_4.6H_2O$.	31	1.02	2	(137)
K_2CrO_4.....	46	0.78	2	(137, 240)
$K_2Cr_2O_7$.....	0 to 400	$0.746 + 0.000602t$	2	(98, 137,
				240)
$K_2SO_4.Cr_2(SO_4)_3$.-				
$24H_2O$.....	−150	0.81	5	(67, 137)
	−100	0.92		
	0	1.08		
	+100	1.23		
$K_2B_2O_4$.....	57	0.94	2	(240)
$K_2B_4O_7$.....	57	0.92	2	(240)
$K_2SO_4.Al_2(SO_4)_3$.-				
$24H_2O$.....	−250	0.089	1	(22, 67, 198)
	−200	0.560		
	−150	0.862		
	−100	1.058		
	0	1.355		
	+ 50	1.506		

Substance	t or Δt, °C	c_p, joule/g	± %	Lit.
$K_2O.Al_2O_3.6SiO_2$,				
Microcline.....	0	15.2*	0.5	(318)
	100	17.9		
	200	19.7		
	400	22.3	1	
	800	24.3		
	1000	24.8		
$K_2O.Al_2O_3.6SiO_2$,				
Orthoclase.....	100	0.86	1	(204, 316)
	200	0.92		
	400	1.03		
	600	1.11		
	800	1.14		
	1000	1.17		
	1100	1.19		
$K_2O.Al_2O_3.6SiO_2$,				
Adular.....	0	0.732		(147, 199,
	100	0.799	2	204, 274)
	200	0.842		
	300	0.937		
	400	1.000		
$K_2SO_4.MgSO_4.6H_2O$	35	1.10	2	(137)
$KNaC_4H_4O_6.4H_2O$..	35	1.37	2	(137)
RbF.....	10	0.482	1	(49)
RbCl.....	10	0.424	1	(49, 137)
RbBr.....	10	0.311	1	(49)
RbI.....	10	0.243	1	(49)
Rb_2CO_3.....	33	0.51	5	(137)
CsF.....	10	0.333	1	(49)
CsCl.....	10	0.312	1	(49)
CsBr.....	10	0.243	1	(49)
CsI.....	10	0.200	1	(49)

Al_2SiO_5, c_p, joule/g ±2% (60, 147, 200)

t, °C	Cyanite	Andalusite	Sillimanite
−250	0.002$_5$	0.012	0.010
−200	0.077$_5$	0.152	0.133
−150	0.24$_5$	0.33$_1$	0.30$_3$
−100	0.42$_5$	0.48$_1$	0.47$_0$
0	0.70$_3$	0.77$_0$	0.72$_2$
+100	0.87$_4$	0.95$_4$	0.87$_5$
200	0.98$_3$	1.07	0.99$_4$
300	1.05$_0$	1.13	1.07$_5$
400	1.09$_6$	1.17	1.125
600	1.16	1.17	1.16
800	1.19	1.17	1.17
1000	1.23	1.17	1.17
1100	1.24	1.17$_5$	1.17
1200	1.25	1.17$_5$	1.17

* Molecular heat/number of atoms in molecule.

C-TABLE, C-ARRANGEMENT (*v.* Vol. III, p. viii)

Formula	Name	t, °C	c_p, joule/g	± %	Lit.
CCl_4	Carbon tetrachloride.....	−240	0.055	5	(143)
		−200	0.340	2	
		−160	0.55		
		−120	0.68		
		− 80	0.76		
		− 40	0.84		
CH_2N_2	Cyanamide.....	20	2.29	2	(211)
CH_2O_2	Formic acid.....	− 22	1.62	3	(177)
		0	1.80		
CH_4	*v.* p. 86.				
CH_4N_2O	Urea.....	20	1.34	1	(166)
C_2Cl_4	Tetrachloroethylene.....	−40 to 0	$0.828 + 0.00075t$	3	(240)
C_2Cl_6	Hexachloroethane.....	25	0.73	2	(137)
$C_2HCl_3O_2$	Trichloroacetic acid.....	solid	1.92	3	(233)

Formula	Name	t, °C	c_p, joule/g	± %	Lit.
$C_2H_2Cl_2O_2$	Dichloroacetic acid	solid	1.70	2	(233)
$C_2H_2O_4$	Oxalic acid	−200 to 50	$1.084 + 0.00319t$	0.5	(194, 195)
$C_2H_2O_4.2H_2O$	Oxalic acid	−200	0.489	1	(120, 194, 195)
		−100	1.000	0.5	
		0	1.414		
		+ 50	1.61	1	
		100	1.74		
$C_2H_3ClO_2$	Chloroacetic acid	60	1.52	2	(233)
$C_2H_3Cl_3O_2$	Chloral hydrate	32	0.89	1	(27, 258)
$C_2H_4N_4$	Dicyandiamide	0 to 204	1.91	1	(211)
$C_2H_4O_2$	Acetic acid	−200 to +25	$1.382 + 0.00336t$	2	(68, 86, 92, 105, 178, 219)
C_2H_6O	Ethyl alcohol (crystalline)	−190	0.970	0.5	(95)
		−180	1.037		
		−160	1.179		
		−140	1.330		
		−130	1.572		
	(vitreous)	−190	1.09	1	(95)
		−180	1.24		
		−175	1.59		
		−170	1.67		
$C_2H_6O_2$	Glycol	−190 to −40	$1.53 + 0.00459t$	2	(219, 306)
$C_3H_3N_3O_3$	Cyamelide	40	1.10	2	(211)
$C_3H_3N_3O_3$	Cyanuric acid	40	1.33	2	(211)
$C_3H_4O_4$	Malonic acid	20	1.15	2	(120)
$C_3H_6N_6$	Melamine	40	1.47	2	(211)
C_3H_6O	Acetone	−210 to −80	$2.260 + 0.0655t$	2	(219)
$C_3H_6O_2$	Propionic acid	− 33	3.04	2	(177)
C_3H_8O	*n*-Propyl alcohol	−200	0.71	3	(95)
		−175	1.52		
		−150	1.97		
		−130	2.08		
	Isopropyl alcohol	−200 to −160	$0.212 + 0.0069t$		(219)
$C_3H_8O_3$	Glycerol	−265	0.038	10	(93, 282, 283)
		−260	0.090		
		−250	0.197		
		−220	0.355	4	
		−200	0.48		
		−100	0.91	2	
		0	1.38		
$C_4H_6O_2$	Crotonic acid	38 to 70	$2.178 - 0.000825t$	2	(159)
$C_4H_6O_4$	Succinic acid	0 to 160	$1.039 + 0.00641t$	2	(114, 120)
$C_4H_6O_4$	Dimethyl oxalate	10 to 50	$0.887 + 0.0184t$	2	(114)
$C_4H_6O_6$	Tartaric acid	36	1.20	2	(137)
$C_4H_6O_6.H_2O$	Tartaric acid	−150	0.468	2	(86, 137)
		−100	0.711	1	
		− 50	0.966		
		0	1.288	0.5	
		+ 50	1.53	1	
$C_4H_7Cl_3O_2$	Chloral alcoholate	78	2.13	2	(32)
$C_4H_{10}O$	Trimethyl carbinol	− 4	2.34	2	(92)
$C_4H_{10}O_4$	Erythritol	60	1.47	3	(151)
$C_5H_8O_4$	Glutaric acid	20	1.25	2	(120)
$C_5H_8O_4$	Pyrotartaric acid	20	1.26	2	(120)
$C_6H_3N_3O_7$	Picric acid	−100	0.690	2	(293)
		0	1.004		
		+ 50	1.100		
		100	1.243	3	
		120	1.388		
C_6H_4BrCl	*o*-Bromochlorobenzene	− 34	0.803	1	(188, 189)
C_6H_4BrCl	*m*-Bromochlorobenzene	− 52	0.627	1	(188, 189)
C_6H_4BrCl	*p*-Bromochlorobenzene	− 40	0.629	1	(188, 189)
		0	0.713		
		+ 40	0.756		
		60	0.797		

Formula	Name	t, °C	c_p, joule/g	± %	Lit.
C_6H_4BrI	*o*-Bromoiodobenzene	−50 to 0	$0.5970 + 0.00104t$	1	(188, 189)
C_6H_4BrI	*m*-Bromoiodobenzene	−75 to −15	0.597	1	(188, 189)
C_6H_4BrI	*p*-Bromoiodobenzene	−40 to 50	$0.4859 + 0.00133t$	1	(188, 189)
$C_6H_4Br_2$	*o*-Dibromobenzene	− 36	1.04	2	(188, 189)
$C_6H_4Br_2$	*m*-Dibromobenzene	− 25	0.56	2	(188, 189)
$C_6H_4Br_2$	*p*-Dibromobenzene	−50 to 50	$0.582 + 0.0016t$	1	(37, 188, 189)
$C_6H_4Cl_2$	*o*-Dichlorobenzene	− 48.5	0.774	2	(188, 189)
$C_6H_4Cl_2$	*m*-Dichlorobenzene	− 52	0.778	2	(188, 189)
$C_6H_4Cl_2$	*p*-Dichlorobenzene	−50 to 53	$0.917 + 0.0086t$	2	(188, 189)
$C_6H_4I_2$	*o*-Diiodobenzene	−50 to 15	$0.456 + 0.0011t$	2	(188, 189)
$C_6H_4I_2$	*m*-Diiodobenzene	−52 to −42	$0.42 + 0.0011t$	2	(188, 189)
$C_6H_4I_2$	*p*-Diiodobenzene	−50 to 80	$0.424 + 0.0012t$	2	(188, 189)
$C_6H_4N_2O_4$	*o*-Dinitrobenzene	−160 to M. P.	$1.054 + 0.00349t$	3	(3, 4)
$C_6H_4N_2O_4$	*m*-Dinitrobenzene	−160 to M. P.	$1.038 + 0.00322t$	3	(3, 4)
$C_6H_4N_2O_4$	*p*-Dinitrobenzene	119 to M. P.	$1.083 + 0.0024t$	2	(4)
$C_6H_4O_2$	Quinone	−250	0.130	3	(34, 141)
		−225	0.343		
		−200	0.473		
		−150 to M. P.	$1.18_2 + 0.0034_8t$	3	
C_6H_5BrO	Bromophenol	32	1.10	3	(315)
C_6H_5I	Iodobenzene	40	0.80	2	(224)
$C_6H_5NO_2$	Nitrobenzene	10	1.50		
		20	1.46		
		40	1.39		
		60	1.38		
		80	1.40		
		100	1.49		
		120	1.65		
C_6H_6	Benzene, *cf.* p. 86	−250	0.167	5	(4, 37, 38, 68,
		−225	0.38		162, 182, 194,
		−200	0.52		232, 265)
		−150	0.71		
		−100	0.95		
		− 50	1.25		
		0	1.57		
$C_6H_6N_2O_2$	*o*-Nitroaniline	−160 to M. P.	$1.12_5 + 0.0038_5t$	3	(3, 4)
$C_6H_6N_2O_2$	*m*-Nitroaniline	−160 to M. P.	$1.15_0 + 0.0039_6t$	3	(3, 4)
$C_6H_6N_2O_2$	*p*-Nitroaniline	−160 to M. P.	$1.15_5 + 0.0041_8t$	3	(3, 4)
$C_6H_6O_2$	*o*-Dihydroxybenzene	−163 to M. P.	$1.16_5 + 0.0041_0t$	3	(3, 4)
$C_6H_6O_2$	*m*-Dihydroxybenzene	−160 to M. P.	$1.12_6 + 0.0049_5t$	3	(3, 4, 166)
$C_6H_6O_2$	*p*-Dihydroxybenzene	−250	0.103	10	(3, 4, 141, 166)
		−240	0.160	5	
		−220	0.255	5	
		−200	0.339	5	
		−150 to M. P.	$1.12_0 + 0.0039_0t$	3	
C_6H_7N	Aniline	?	3.1	3	(92)
$(C_6H_{10}O_5)_x$	Dextrin	0 to 90	$1.22 + 0.0040t$	2	(167, 284)
$C_6H_{10}O_5$	Levoglucosane	40	2.54	3	(211)
$C_6H_{12}O_6$	Dextrose	−250	0.0648	3	(166, 282)
		−200	0.323	1	
		−100	0.669	0.5	
		0	1.159		
		20	1.257		
$C_6H_{12}O_6$	Levulose	20	1.15	1	(167)
$C_6H_{14}O_6$	Dulcitol	20	1.18	2	(166)
$C_6H_{14}O_6$	Mannitol	0 to 100	$1.31 + 0.00106t$	1	(137, 151, 167)
$C_7H_5ClO_2$	*o*-Chlorobenzoic acid	80 to M. P.	$0.953 + 0.00353t$	2	(4)
$C_7H_5ClO_2$	*m*-Chlorobenzoic acid	94 to M. P.	$0.970 + 0.00305t$	2	(4)
$C_7H_5ClO_2$	*p*-Chlorobenzoic acid	180 to M. P.	$1.01_3 + 0.00232t$	2	(4)
$C_7H_5NO_4$	*o*-Nitrobenzoic acid	−163 to M. P.	$1.07_3 + 0.0035_7t$	3	(3, 4)
$C_7H_5NO_4$	*m*-Nitrobenzoic acid	66 to M. P.	$1.07_9 + 0.0038_3t$	3	(3, 4)
$C_7H_5NO_4$	*p*-Nitrobenzoic acid	−160 to M. P.	$1.03_5 + 0.0032_3t$	3	(3, 4)

Formula	Name	t, °C	c_p, joule/g	± %	Lit.
$C_7H_5N_3O_6$	Trinitrotoluene	−100	0.71*	5	(75, 238, 293)
		− 50	1.06		
		0	1.30		
		+100	1.61	8	
$C_7H_5N_5O_8$	Tetryl	−100	0.761*	1	(238, 293)
		− 50	0.832		
		0	0.887		
		+100	0.987		
$C_7H_6O_2$	Benzoic acid	20 to M. P.	$1.200 + 0.0021t$	2	(4, 120)
$C_7H_7NO_2$	*o*-Aminobenzoic acid	85 to M. P.	$1.064 + 0.00570t$	5	(4)
$C_7H_7NO_2$	*m*-Aminobenzoic acid	120 to M. P.	$1.059 + 0.00512t$	5	(4)
$C_7H_7NO_2$	*p*-Aminobenzoic acid	128 to M. P.	$1.203 + 0.00368t$	5	(4)
$C_7H_8O_2$	Dimethylpyrone	50	1.54	2	(237)
C_7H_9N	*p*-Toluidine	0	1.41	5	(20)
		20	1.62	2	
		40	1.84	5	
$C_8H_6O_4$	Phthalic acid	20	0.97	2	(120)
$C_8H_7N_3O_6$	Trinitroxylene	−185 to 23	1.01†	2	(238)
		20 to 50	1.77†	5	
$C_8H_8O_2$	*o*-Toluic acid	54 to M. P.	$1.160 + 0.00504t$	3	(4)
$C_8H_8O_2$	*m*-Toluic acid	54 to M. P.	$0.999 + 0.00818t$	3	(4)
$C_8H_8O_2$	*p*-Toluic acid	130 to M. P.	$1.133 + 0.00443t$	3	(4)
$C_8H_9NO_2$	Hydroxyacetanilide	41 to M. P.	$1.043 + 0.00646t$		(4)
$C_8H_{16}O_2$	Caprylic acid	− 2	2.63	3	(105)
$C_{10}H_7Br$	β-Bromonaphthalene	41	1.09	2	(224)
$C_{10}H_7NO_2$	Nitronaphthalene	0 to 55	$0.989 + 0.0090t$	2	(21, 55)
$C_{10}H_8$	Naphthalene	−130 to M. P.	$1.176 + 0.00464t$	5	(4, 20, 37, 67, 293)
$C_{10}H_8O$	α-Naphthol	50 to M. P.	$1.004 + 0.00615t$	2	(4)
$C_{10}H_8O$	β-Naphthol	61 to M. P.	$1.056 + 0.00534t$	2	(4)
$C_{10}H_9N$	α-Naphthylamine	0 to 50	$1.13 + 0.013t$	2	(21, 55)
$C_{10}H_{14}O$	Thymol	0 to 49	$1.32 + 0.013t$	3	(19, 51)
$C_{10}H_{16}$	Camphene	35	1.59	2	(258)
$C_{10}H_{20}O_2$	Capric acid	8	2.91	3	(105)
$C_{12}H_{10}$	Diphenyl	40	1.61	2	(87)
$C_{12}H_{10}N_2$	Azobenzene	28	1.38	1	(38, 87)
$C_{12}H_{10}O_4$	Quinhydrone	−250	0.0690	1	(141)
		−225	0.2558		
		−200	0.410		
		−100	0.799		
		0	1.071		
$C_{12}H_{11}N$	Diphenylamine	26	1.41	2	(20, 55)
$C_{12}H_{14}O_4$	Apiol	10	1.25	3	(291)
$C_{12}H_{22}O_{11}$	Lactose	20	1.20	1	(167)
$C_{12}H_{22}O_{11}.H_2O$	Lactose	20	1.25	1	(167)
$C_{12}H_{22}O_{11}$	Maltose	20	1.34	1	(167)
$C_{12}H_{22}O_{11}$	Sucrose	20	1.25	1	(167)
$C_{12}H_{24}O_2$	Lauric acid	−30 to 40	$1.80 + 0.000114t$	1	(105, 177)
$C_{13}H_8N_3O_{15}$	1 Tetryl + 1 Picric acid	−100 to 100	$1.06 + 0.0030t$	2	(293)
$C_{13}H_{10}O$	Benzophenone	−150	0.48	5	(195, 291)
		−100	0.72	3	
		− 50	0.92	1	
		0	1.15		
		+ 20	1.27		
$C_{13}H_{10}O_3$	Salol	32	1.21	1	(55)
$C_{14}H_8O_2$	Anthraquinone	0 to 270	$1.079 + 0.0029t$	1	(121)
$C_{14}H_{10}$	Anthracene	50	1.288	0.5	(121)
		100	1.464		
		150	1.597		
$C_{14}H_{14}$	Dibenzyl	28	1.52	1	(38)
$C_{14}H_{28}O_2$	Myristic acid	0 to 35	$1.593 + 0.0228t$	2	(105, 268, 285)
$C_{16}H_{32}O_2$	Palmitic acid	−180	0.70	2	(105, 219)
		−140	0.87		
		−100	1.05		

* There is serious discrepancy between the authors. †Mean over the range.

Formula	Name	t, °C	c_p, joule/g	±%	Lit.
$C_{16}H_{32}O_2$	Palmitic acid.—(*Cont'd*)	− 50	1.28		
		0	1.60		
		+ 20	1.80		
$C_{16}H_{34}$	Hexadecane	19	2.07	2	(16)
$C_{17}H_{12}O_3$	Betol	−150	0.54	2	(193, 195)
		−100	0.70		
		0	1.04		
		+ 50	1.29		
$C_{18}H_{36}O_2$	Stearic acid	15	1.67	4	(105)
$C_{19}H_{16}$	Triphenylmethane	0 to 91	$0.791 + 0.0114t$	0.5	(121)
$C_{21}H_{16}N_{11}O_{20}$	1 Tetryl + 2 TNT	−100	0.72	5	(293)
		0	1.17		
		+ 50	1.36		
$C_{27}H_{54}O_2$	Cerotic acid	15	1.62	3	(105)

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THERMAL PROPERTIES OF SILICA

ROBERT B. SOSMAN

HEAT CAPACITY (2, 3, 4, 8, 9, 10, 11, 12, 14, 16, 17, 18, 19, 20, 21, 23, 24, 25, 26)

VALUES OF c_p AT t, °C, JOULE/G

t, °C	Quartz	Cristobalite*	Vitreous
−255			0.0200
−250	0.0226	0.0284	0.0322
−243	.0393	.0468	0.0531
−233	.0669	.0761	0.0828
−223	.0983	.106	0.112
−200	.171	.184	0.181
−150	.324	.339	0.332
−100	.465	.481	0.472
− 50	.590	.606	0.594
0	.696	.717	0.693
+ 50	.782	.790	0.773
100	.854	.882	0.840
150	.917	.978	0.899
200	.973	1.095	0.947
250	1.022	1.033	0.988
300	1.063	1.049	1.027
350	1.098	1.070	1.060
400	1.129	1.091	1.088
450	1.162	1.112	1.112
500	1.217	1.133	1.131
550	1.321	1.150	1.141
573	1.422(?)		
600	1.133	1.162	1.150
700	1.146	1.187	1.175
800	1.157	1.208	1.196
900	1.168	1.221	1.208
1000	1.178	1.225	1.221
1100	1.187	1.230	1.229
1200	1.194	1.237	1.267
1300	1.202	1.25	1.321
1400	1.212	1.26	1.371
1500		1.27	1.417
1600		1.27	1.447
1700		1.27	1.472

* Made at 1100°C.

VALUES OF c_m BETWEEN 0 AND t, °C, JOULE/G

t, °C	Quartz	Cristobalite*	Vitreous
−250	0.382	0.399	0.391
−200	.454	.470	.460
−150	.523	.539	.527
−100	.588	.602	.590
− 50	.645	.661	.646
0	.696	.711	.693
+ 50	.740	.750	.736
100	.779	.795	.773
150	.815	.836	.807
200	.847	.888	.836
225		.916†	
		.937‡	
250	.878	.949	.861
300	.905	.966	.886
350	.930	.978	.907
400	.953	.991	.928
450	.974	1.003	.949
500	.995	1.016	.966
550	1.019	1.029	.983
573	1.033†		
	1.052‡		
600	1.055	1.037	.995
700	1.067	1.058	1.020
800	1.077	1.075	1.041
900	1.085	1.091	1.058
1000	1.094	1.104	1.075
1100	1.103	1.116	1.087
1200	1.110	1.125	1.100
1300	1.117	1.133	1.116
1400	1.125	1.141	1.129
1500		1.150	1.150
1600		1.158	1.166
1700		1.166	1.183

* Made at 1100°C. † Low modification. ‡ High modification.

LATENT HEATS OF TRANSFORMATION (3, 13, 15, 16, 24, 25)

Transformation	t, °C	Heat absorbed at $t°$, joule/g
High-cristobalite→liquid (fusion)	1710	71
High-quartz→liquid (fusion)	1710*	210
Low-quartz→high-quartz	573	10.5
Low-1100°-cristobalite → high-1100° cristobalite†	230	4.2
Low-1600°-cristobalite → high-1600°-cristobalite†	270	10.5

* This temperature is not the melting point of quartz; it is selected merely for the sake of the comparison with cristobalite. The difference in heat content between quartz and liquid or vitreous silica at any other temperature can be calculated from this with the aid of the heat capacities.

† Cristobalites made at different temperatures differ in inversion point and in various other ways.

THERMAL CONDUCTIVITY (1, 5, 6, 7, 22)

Values of 10^3k; unit of k, joule cm^{-2} sec^{-1} $(°C\ cm^{-1})^{-1}$

t, °C	Quartz ∥ to axis	Quartz ⊥ to axis	Vitreous
−252		2848	
−250		2135	*ca.* 5.4
−240		858	
−200	*ca.* 630	276	6.3
−150	310	151	8.4
−100	218	109	10.5
− 50	167	86	12.5
0	134	71	14.2
+ 50	107	62	15.9
100	88	55	*ca.* 19

LITERATURE

(For a key to the periodicals see end of volume)

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THE HEAT CAPACITY OF CHEMICAL COMPOUNDS IN THE LIQUID STATE

HOWARD T. BARNES

A value in the c_p column represents the heat capacity in joules per gram per deg C under atmospheric pressure and at $t°$ (or the mean c_p over $\Delta t°$); unless the value is enclosed in parentheses, in which case it represents merely the parameter c_0 in the equation

$$c_p = c_0 + at + bt^2 + \ldots$$

which equation is valid over the range given.

Une valeur mentionnée dans la colonne des c_p, représente la capacité calorifique en joules par gramme et par degré C, sous la pression atmosphérique et à $t°$ (ou la valeur moyenne c_p pour $\Delta t°$), à moins que la valeur ne soit comprise entre parenthèses, auquel cas elle représente seulement le paramètre c_0 de l'équation

$$c_p = c_0 + at + bt^2 + \ldots$$

cette équation étant valable pour l'intervalle donné.

Ein in der c_p-Kolonne stehender Wert bedeutet den Wärmeinhalt in Joule pro Gramm pro Grad C, unter dem Druck 1 Atmosphäre bei $t°$ (oder das Mittel c_p im $\Delta t°$ Intervall). In Klammer gesetzte Werte bedeuten, dass nur etwa der Parameter c_0 der Gleichung

$$c_p = c_0 + at + bt^2 + \ldots$$

vorliegt. Diese gilt innerhalb des angegebenen Temperaturbereiches.

I valori della colonna c_p rappresentano la capacità termica in joules per ogni grammo e grado centigrado alla pressione atmosferica e a $t°$ (oppure il c_p medio nell' intervallo $\Delta t°$). I valori racchiusi tra parentesi rappresentano soltanto il termine c_0 della equazione

$$c_p = c_0 + at + bt^2 + \ldots$$

la quale è valida entro i limiti dati.

ℬ-TABLE

Substance	t or Δt, °C	c_p, joule/g	± %	Lit.
H_2O	*v.* p. 113			
H_2O_2	0–18	2.42	2	(161)
HCl, HBr, HI	*v.* p. 86			
ICl	15–77	0.661	1	(286)
SO_2	*v.* p. 114			
H_2SO_4	*v.* p. 114			
$H_2S_2O_7$	35	1.4	10	(6)
S_2Cl_2	12–70	0.921	1	(207)
$SOCl_2$	17–60	1.013	1	(208)
SO_2Cl_2	15–63	0.975	1	(208)
NO	*v.* p. 86			
NH_3	*v.* p. 86, 114			
CO	*v.* p. 86			
CO_2	*v.* p. 114			
SiO_2	*v.* p. 105			
$SiCl_4$	12–50	0.837	1	(205)
$(CH_3)_4SiO_4$	23–115	2.097	0.5	(134)
$TiCl_4$	13–99	0.804	1	(240)
$SnCl_4$	14–98	0.619	1	(240)
$PbCl_2$	540	0.506	1	(98)
$PbBr_2$	550	0.326	1	(98)
TlCl	480	0.247	1	(97)
TlBr	500	0.335	1	(97)
AgCl	490	0.540	1	(97)
AgBr	500	0.318	1	(98)
$AgNO_3$	250	0.783	1	(109)
	>218	0.816	1	(98)
$Mg_aSi_bO_c$	*v.* Vol. II, p. 101			
$CaCl_2.6H_2O$	33–99	2.310	1	(228)
$Ca_aSi_bO_c$	*v.* Vol. II, p. 101			
$LiNO_3$	280	1.632	1	(98)
$NaClO_3$	280	1.360	1	(98)
$Na_2S_2O_3.5H_2O$	13–98	2.385	1	(303)
$NaNO_3$	350	1.800	1	(98)
$NaC_2H_3O_2$	61.8	3.541	0.5	(96)
$Na_aSi_bAl_cO_d$	*v.* Vol. II, p. 101			
KNO_3	380	0.139	5	(98)
$K_aSi_bAl_cO_d$	*v.* Vol. II, p. 101			
$K_2Cr_2O_7$	>397	0.140	1	(98)

C-TABLE, C-ARRANGEMENT (*v.* Vol. III, p. viii)

$c_p = c_0 + at + bt^2$

Formula	Name	t or Δt, °C	c_p, joule/g	± %	10^3a	Range, °C	Lit.
CCl_4	Carbon tetrachloride	0	0.827	0.5	0.8	20–60	(247)
		20	0.841	1	0.13	0–70	(182)
		20	0.833	0.5			(319)
		30	0.837	0.2	1.97	20–60	(321)
CS_2	Carbon disulfide	*v.* p. 114					
$CHCl_3$	Chloroform	0	0.971	0.5	0.322*	20–40	(247)
		15	0.946	0.5	1.38	−30 to 60	(302)
		20	0.978	0.5			(275)
		20	0.968	0.5			(319)
		30	0.979	0.2	1.27	20–60	(321)
CH_2Cl_2	Methylene chloride	15–40	1.205	0.5			(31)
CH_2O_2	Formic acid	0	2.078	0.5	2.97	40–140	(266)
		0	1.83	1			(250)
		15.5	2.139	0.4			(94)
		20–100	2.201	1			(250)
CH_3NO	Formamide	19	2.306	0.5			(310)
CH_3NO_2	Nitromethane	17	1.724	0.5			(310)
	($CaCl_2$-dried)	0	(1.664)		−1.42†	30–70	(320)
	(P_2O_5-dried)	0	(1.76)		−3.19‡	15–70	(320)
CH_4	Methane	*v.* p. 86					
CH_4O	Methyl alcohol	*v.* p. 114					
C_2Cl_4	Tetrachloroethylene	20	0.883	1			(250)
		20	0.904	0.4			(118)
C_2HCl_3	Trichloroethylene	20	0.933	0.4			(118)
C_2HCl_3O	Chloral	17–53	1.046	0.5			(27)
$C_2H_2Cl_2O_2$	Dichloroacetic acid	21–106	1.465	0.5			(156)
		21–196	1.464	0.5			(155)
$C_2H_2Cl_4$	Tetrachloroethane	20	1.122	0.4			(118)
C_2H_3ClO	Acetyl chloride	0	1.419	1.0			(250)
$C_2H_3Cl_3$	Trichloroethane	20	1.113	0.5			(118)
$C_2H_3Cl_3O_2$	Chloral hydrate	55–88	1.967	0.5			(27)
C_2H_3N	Acetonitrile	21–76	2.264	0.5			(153)
$C_2H_4Br_2$	Ethylene bromide	8–95	0.766	1.0			(30)
		13–106	0.734	0.5			(247)
		20	0.728	0.5			(247)
		− 30	1.168	0.5			(247)
		+ 20	1.258	0.5			(275)
$C_2H_4Cl_2$	Ethylene chloride	30	1.276	0.5			(247)
		50	1.316	0.5			(275)
		60	1.335	0.5			(247)
$C_2H_4O_2$	Acetic acid	*v.* p. 114					
$C_2H_4O_2$	Methyl formate	13–29	2.159	0.5			(33)
C_2H_5Br	Ethyl bromide	−100	0.816	1.0			(21)
		− 20	0.866	1.0			(21)
		5–10	0.906	0.5			(251)
		10–15	0.894	0.5			(241)
		15–20	0.901	0.5			(241)
C_2H_5Cl	Ethyl chloride	−28 to +4	1.790	0.5			(247)
		0	1.542	0.5	2.43	−30 to 40	(131)
C_2H_5I	Ethyl iodide	−30	0.656	0.5			(247)
		60	0.718	0.5			(247)
		0	0.676	0.5	6.91	−30 to 60	(247)
C_2H_6O	Ethyl alcohol	*v.* p. 114					
$C_2H_6O_2$	Glycol	0	2.277	0.5	5.0	−20 to 200	(91, 152, 276)
		−11.1	2.247	1			(219)
		+ 2.5	2.310	1			(219)
		5.1	2.327	1			(219)
		14.9	2.390	1			(219)
		19.9	2.406	1			(219)
$C_3H_3Cl_3O_2$	Methyl trichloroacetate	20	1.117	0.5	1.69	10–140	(266)
$C_3H_4Cl_2O_2$	Methyl dichloroacetate	20	1.302	0.5	1.6	10–140	(266)
C_3H_5Cl	Allyl chloride	0	1.310	1			(250)

* $10^6b = 1.55$. † $10^6b = 34.2$. ‡ $10^6b = 25.8$.

Formula	Name	t or Δt, °C	c_p, joule/g	± %	10^3a	Range, °C	Lit.
$C_3H_5ClO_2$	Methyl chloroacetate	20	1.600	0.5	1.6	10–160	(266)
C_3H_5N	Propionitrile	0	2.128	0.5			(247)
		19–95	2.252	0.5			(155)
C_3H_6O	Allyl alcohol	0	1.615	1.0			(250)
		21–96	2.785	0.5			(152)
C_3H_6O	Propionaldehyde	0	2.185	1			(250)
C_3H_6O	Acetone	3–22.6	2.151	0.5			(158)
		0	(2.118)	0.5	3.2	−30 to +60	(247)
		24.2–49.4	2.251	1			(158)
		20	2.210				(301)
		20	2.166	0.5			(319)
		0	2.134	0.5	3.35	22–50	(302)
$C_3H_6O_2$	Propionic acid	0	1.858	0.5	0.593	10–140	(265)
		20–137	2.342	0.5			(155)
$C_3H_6O_2$	Ethyl formate	14–49	2.136	0.5			(33)
		−20 to +14	1.909	0.5			(187)
$C_3H_6O_2$	Methyl acetate	15	1.96				(269)
$C_3H_6O_3$	Dimethyl carbonate	19.8–88	1.892	0.5			(155)
C_3H_8	Propane	0	2.41	2	6.3	−30 to 20	(63)
C_3H_8O	Propyl alcohol	*v.* p. 114					
$C_3H_8O_2$	Methylal	15–41	2.180	1			(21)
$C_3H_8O_3$	Glycerol	*v.* p. 114					
$C_4H_5Cl_3O_2$	Ethyl trichloroacetate	10–81	1.235	0.5			(266)
		9–139	1.280	0.5			(266)
		20	1.193	0.5	1.6	10–140	(266)
$C_4H_6Cl_2O_2$	Ethyl dichloroacetate	20	1.377	0.5			(266)
$C_4H_6O_2$	Crotonic acid	71.4	2.093	1.0	6.37		(159)
$C_4H_7ClO_2$	Ethyl chloroacetate	9–138	1.749	0.5			(266)
		20	1.666	0.5	1.6	10–140	(266)
C_4H_7N	*n*-Butyronitrile	21–113	2.290	0.5			(155)
C_4H_8O	Methyl ethyl ketone	20–78	2.299	0.5			(152)
$C_4H_8O_2$	*n*-Butyric acid	0	1.858	0.5			(265)
		40	2.097	0.5			(265)
		20–100	2.155	0.5			(250)
$C_4H_8O_2$	Isobutyric acid	20	1.883	1			(250)
$C_4H_8O_2$	Ethyl acetate	20	1.921	0.5			(265)
		20	2.000	0.5			(300)
$C_4H_8O_2$	Methyl propionate	20	1.921	0.5			(265)
$C_4H_8O_2$	*n*-Propyl formate	20	1.921	0.5			(265)
C_4H_9Cl	*n*-Butyl chloride	20	1.887	0.5			(301)
C_4H_9NO	Methyl ethyl ketoxime	21.8–151.5	2.722	0.5			(155)
C_4H_{10}	*n*-Butane	0	2.30	2	8.0	−15 to 20	(63)
	Isobutane	0	2.30	2	19		
$C_4H_{10}O$	*n*-Butyl alcohol	21–115	2.876	0.5			(250)
		21–115	2.883	0.5			(152)
		30	2.436	0.2	11.01*	30–80	(321)
		−76.2	1.854	0.5			(218)
		−33.3	1.896	0.5			(218)
		2.3	2.201	0.5			(218)
		19.2	2.356	0.5			(218)
$C_4H_{10}O$	Isobutyl alcohol	21–109	2.996	0.5			(152)
		30	2.525		13.68†	20–80	(321)
$C_4H_{10}O$	Ether	−100	2.147	1			(21)
		− 50	2.164	1			(21)
		− 5	2.205	0.5			(187)
		0	2.189	1			(21)
		0	2.214	0.5			(247)
		+ 30	2.289	0.5			(247)
		80	2.888	0.5			(289)
		120	3.361	0.5			(289)
		140	3.440	0.5			(115)
		180	4.357	0.5			(115)

* $10^6b = 7.5$. † $10^6b = 10.5$.

Formula	Name	t or Δt, °C	c_p, joule/g	± %	10^3a	Range, °C	Lit.
		0	(1.967)	0.5	0.75	5–70	(241)
		5–10	1.973	0.5			(241)
$C_4H_{10}S$	Ethyl sulfide	10–15	1.989	0.5			(241)
		15–20	1.997	0.5			(241)
		20–70	2.003	0.5			(241)
$C_4H_{11}N$	Diethylamine	22.5	2.168	0.5			(187)
$C_5H_4O_2$	Furfural	0	1.540	1			(250)
		20–100	1.749	1			(250)
$C_5H_5Cl_3O_2$	Allyl trichloroacetate	20	1.205	0.5			(266)
C_5H_5N	Pyridine	20	1.695	0.5	1.6	20–110	(301)
		21–108	1.804	0.5			(153)
		0–20	1.653	0.5			(45)
$C_5H_6Cl_2O_2$	Allyl dichloroacetate	20	1.389	0.5	1.6	10–140	(266)
$C_5H_7ClO_2$	Allyl chloroacetate	20	1.657	0.5	1.6		
$C_5H_7Cl_3O_2$	Propyl trichloracetate	20	1.243	0.5	1.6		
$C_5H_6Cl_2O_2$	Propyl dichloroacetate	20	1.427	0.5	1.6		
$C_5H_8O_2$	Allyl acetate	0	1.802	0.5	3.68		
$C_5H_9ClO_2$	Propyl chloroacetate	20	1.733	0.5	1.6		
C_5H_9N	Valeronitrile	23–121	2.176	0.5			(133)
C_5H_{10}	Amylene	0	1.180	1.0			(250)
$C_5H_{10}O$	Diethyl ketone	20–98.5	2.332	0.5			(152)
$C_5H_{10}O$	Methyl isopropyl ketone	20–91	2.198	0.5			(152)
$C_5H_{10}O_2$	Isovaleric acid	20	1.938	0.5	5.93	10–140	(266)
		23–93	2.469	0.5			(105)
$C_5H_{10}O_2$	*n*-Butyl formate	20	1.921	0.5			(265)
$C_5H_{10}O_2$	Ethyl propionate	20	1.921	0.5			(266)
$C_5H_{10}O_2$	Methyl *n*-butyrate	20	1.921	0.5			(265)
$C_5H_{10}O_2$	*n*-Propyl acetate	20	1.921	0.5			(265)
$C_5H_{10}O_3$	Diethyl carbonate	0	1.030	1.0			(250)
		20–100	1.942	1.0			(250)
		20.2–123	1.986	0.5			(152)
$C_5H_{11}N$	Piperidine	20–98	2.189	0.5			(153)
C_5H_{12}	Isopentane	0	2.145	0.5			(268)
		8	2.204	0.5			(308)
$C_5H_{12}O$	Isoamyl alcohol	40	1.933	1.0	10.21*	0–130	(21)
		0	(2.101)	0.5			(265)
		20	2.239	0.5			(265)
		10–117	2.900	0.5			(247)
		21–130	2.911	0.5			(152)
		75.5	2.878	1.0			(250)
		30	2.385	0.2	10.67†	30–80	(321)
		47.9	2.77				(158)
$C_5H_{12}O$	*tert.*-Amyl alcohol	20–99	3.15	0.5			(152)
$C_5H_{12}O$	*d-prim.*-Amyl alcohol	22–125	2.978	0.5			(152)
$C_5H_{13}N$	Isoamylamine	22–91	2.570	0.5			(134)
C_6H_4BrCl	*o*-Bromochlorobenzene	0	0.899	0.5	0.98	0–100	(188)
C_6H_4BrCl	*m*-Bromochlorobenzene	0	0.888	0.5	0.98		
		0	(0.639)	0.5	0.557		
C_6H_4BrI	*o*-Bromoiodobenzene	5–100	0.668	0.5			(188)
		3.2–64.6	0.658	0.5			(188)
		1.8–34	0.657	0.5			(188)
		0	(0.635)	0.5	0.557‡	0–100	(188)
C_6H_4BrI	*m*-Bromoidobenzene	5–100	0.663	0.5			(188)
		3.2–64.5	0.652	0.5			(188)
		1.7–34.1	0.644	0.5			(188)
		1.7–36.2	0.624	0.5			(188)
$C_6H_4Br_2$	*o*-Dibromobenzene	0	0.753	0.5	0.896	0–100	(188)
$C_6H_4Br_2$	*m*-Dibromobenzene	0	0.734	0.5	0.896		
$C_6H_4Cl_2$	*o*-Dichlorobenzene	0	1.131	0.5	1.27		
$C_6H_4Cl_2$	*m*-Dichlorobenzene	0	1.131	0.5	1.27		
$C_6H_4Cl_2$	*p*-Dichlorobenzene	53–99	1.247	0.5			(188)
$C_6H_4I_2$	*o*-Diiodobenzene	0	0.568	0.5	0.325	0–100	(188)
$C_6H_4I_2$	*m*-Diiodobenzene	34.2–99.6	0.586	0.5			(188)
$C_6H_4N_2O_4$	*o*-Dinitrobenzene	0	(1.462)	1	1.39	M. P. to 357	(4)
$_2O_4$	*m*-Dinitrobenzene	M. P.	1.697	1	0.0	M. P. to 235	(4)

= 17. † 10^6b = 3.85. ‡ 10^6b = 1.3.

Formula	Name	t or Δt, °C	c_p, joule/g	± %	10^3a	Range, °C	Lit.
$C_6H_4N_2O_4$	*p*-Dinitrobenzene	0	(1.169)	1	2.76	M. P. to 384	(4)
$C_6H_4O_2$	Quinone	0	(1.355)	1	3.41	M. P. to 273	(4)
C_6H_5Br	Bromobenzene	0	0.900	1			(250)
		20	0.965	0.5			(319)
		20–100	1.030	1			(250)
		16.9–65	1.006	0.5			(139)
C_6H_5BrO	Bromophenol	18–77	1.322	1.0			(315)
C_6H_5Cl	Chlorobenzene	0	1.147	1.0			(250)
		0	1.250	0.5	3.10	10–140	(266)
		20	1.294	0.5			(319)
C_6H_5ClO	*o*-Chlorophenol	0–20	1.678	0.5			(45)
$C_6H_5NO_2$	Nitrobenzene	10	1.499	0.5			(275)
		30	1.420	0.5			(275)
		50	1.380	0.5			(275)
		70	1.381	0.5			(275)
		90	1.435	0.5			(275)
		120	1.648	0.5			(275)
C_6H_6	Benzene	*v.* p. 115					
$C_6H_6Cl_4O_4$	Ethylene dichloroacetate	0	1.348	0.5	1.6	10–140	(266)
$C_6H_6N_2O_2$	*o*-Nitroaniline	0	(1.675)	1	2.65	M. P. to 219	(4)
$C_6H_6N_2O_2$	*m*-Nitroaniline	0	(1.641)	1	2.42	M. P. to 322	(4)
$C_6H_6N_2O_2$	*p*-Nitroaniline	0	(1.787)	1	1.45	M. P. to 343	(4)
C_6H_6O	Phenol	14–26	2.348	0.5			(166)
$C_6H_6O_2$	*o*-Dihydroxybenzene	0	(1.935)	1	2.28	M. P. to 304	(4)
$C_6H_6O_2$	*m*-Dihydroxybenzene	0	(1.891)	1	2.66	M. P. to 310	(4)
$C_6H_6O_2$	*p*-Dihydroxybenzene	0	(2.060)	1	1.67	M. P. to 372	(4)
C_6H_7N	α-Picoline	22–124	1.816	0.5			(133)
C_6H_7N	Aniline	*v.* p. 115					
C_6H_{10}	1, 5-Hexadiene	0	1.703	1.0			(250)
$C_6H_{10}O$	Cyclohexanone	15–18	1.812	0.5			(119)
$C_6H_{10}O$	Mesityl oxide	21–121	2.182	0.5			(152)
$C_6H_{10}O_2$	Allyl propionate	20	1.887	0.5	3.68	10–140	(266)
$C_6H_{10}O_3$	Ethyl acetoacetate	0	1.800	1			(250)
		20–100	1.996	1			(250)
$C_6H_{10}O_4$	Diethyl oxalate	20	1.812	0.5	2.76	10–140	(266)
$C_6H_{11}N$	Capronitrile	18–156	2.268	1.0			(153)
C_6H_{12}	Hexylene	0–50	2.118	0.4			(163)
$C_6H_{12}O$	Cyclohexanol	15–18	1.745	0.5			(119)
$C_6H_{12}O$	Methyl butyl ketone	21–127	2.313	0.5			(155)
$C_6H_{12}O$	Methyl isobutyl ketone	20	1.921	0.5			(265)
$C_6H_{12}O_2$	Caproic acid	29–105	2.231	0.5			(105)
$C_6H_{12}O_2$	Isoamyl formate	16–65	2.130	0.5			(139)
		20	1.921	0.5			(265)
$C_6H_{12}O_2$	Isobutyl acetate	20	1.921	0.5	2.76	0–110	(265)
$C_6H_{12}O_2$	Ethyl butyrate	20	1.921	0.5			(266)
$C_6H_{12}O_2$	Ethyl isobutyrate	20	1.921	0.5			(266)
$C_6H_{12}O_2$	Methyl valerate	20	1.921	0.5			(265)
$C_6H_{12}O_2$	Propyl propionate	20	1.921	0.5			(265)
$C_6H_{12}O_3$	Paraldehyde	0	1.825	1			(250)
C_6H_{14}	*n*-Hexane	0–50	2.205	0.4			(163)
		20–100	2.511	1			(250)
$C_6H_{14}O_2$	Acetal	0	1.954	1			(250)
		19–99	2.1754	0.5			(152)
$C_6H_{15}N$	Dipropylamine	22–100	2.498	0.5			(133)
$C_7H_5ClO_2$	*o*-Chlorobenzoic acid	0	(1.639)	1	1.50	M. P. to 340	(4)
$C_7H_5ClO_2$	*m*-Chlorobenzoic acid	0	(1.115)	1	4.01	M. P. to 359	(4)
$C_7H_5ClO_2$	*p*-Chlorobenzoic acid	M. P.	2.290	1	0.0	M. P. to 505	(4)
C_7H_5N	Benzonitrile	22–186	1.846	0.5			(153)
$C_7H_5NO_4$	*o*-Nitrobenzoic acid	0	(1.315)	1	2.5	M. P. to 386	(4)
$C_7H_5NO_4$	*m*-Nitrobenzoic acid	0	(1.695)	1	2.4	M. P. to 366	(4)
$C_7H_5NO_4$	*p*-Nitrobenzoic acid	M. P.	1.878	1	0.0	M. P. to 484	(4)
$C_7H_5N_3O_6$	2, 4, 6-Trinitrotoluene	?	1.402	0.4			(75)
C_7H_6O	Benzaldehyde	22–172	1.792	0.5			(152)
$C_7H_6O_2$	Salicylaldehyde	18	1.599	0.5			(310)
$C_7H_6O_2$	Benzoic acid	0	(1.774)	1	3.22	M. P. to 322	(4)

Formula	Name	t or Δt, °C	c_p, joule/g	± %	10^3a	Range, °C	Lit.
C_7H_7Cl	Benzyl chloride	0	1.350	0.5	3.1o	10–140	(266)
C_7H_7Cl	Chlorotoluene	0	1.322	0.5	3.1o	10–140	(266)
$C_7H_7NO_2$	*o*-Aminobenzoic acid	M. P.	1.82	2	0.0	M. P. to 305	(4)
$C_7H_7NO_2$	*m*-Aminobenzoic acid	M. P.	1.82	2	0.0	M. P. to 360	(4)
$C_7H_7NO_2$	*p*-Aminobenzoic acid	M. P.	1.86	2	0.0	M. P. to 378	(4)
C_7H_8	Toluene	*v.* p. 115					
C_7H_8O	Benzyl alcohol	20–100	2.139	1.0			(250)
		22–200	2.261	0.5			(152)
C_7H_8O	*o*-Cresol	0–20	2.088	0.5			(45)
C_7H_8O	*m*-Cresol	21–197	2.314	0.5			(153)
		0–20	2.005	0.5			(45)
C_7H_8O	Phenyl methyl ether	0	1.697	0.5	3.6o	10–140	(266)
		20–152	2.021	0.5			(155)
$C_7H_8O_2$	Dimethylpyrone	166	2.3	10.0			(237)
C_7H_9N	Methylaniline	20–197	2.145	0.5			(155)
C_7H_9N	*o*-Toluidine	0	1.90o	1			(250)
		22–195	2.193	0.5			(155)
		40.5	2.084	0.5			(139)
		0	1.969	0.5	2.93	12–139	(265)
C_7H_9N	*p*-Toluidine	43	2.503	1			(20)
		58	2.653	1			(20)
		94	2.231	1			(267)
$C_7H_{12}O$	*o*-Methylcyclohexanone	15–18	1.825	0.5			(119)
$C_7H_{12}O$	*m*-Methylcyclohexanone	15–18	1.846	0.5			(119)
$C_7H_{12}O$	*p*-Methylcyclohexanone	15–18	1.846	0.5			(119)
$C_7H_{12}O_2$	Allyl butyrate	20	1.887	0.5	3.68	10–140	(266)
$C_7H_{12}O_2$	Allyl isobutyrate	20	1.875	0.5	3.68		
$C_7H_{12}O_4$	Diethyl malonate	20	1.812	0.5	2.76		
C_7H_{14}	Heptylene (B. P., 98°)	0–50	2.042	0.4			(163)
$C_7H_{14}O$	*o*-Hexahydrocresol	15–18	1.749	0.5			(119)
$C_7H_{14}O$	*m*-Hexahydrocresol	15–18	1.766	0.5			(119)
$C_7H_{14}O$	*p*-Hexahydrocresol	15–18	1.770	0.5			(119)
$C_7H_{14}O$	Heptaldehyde	0	1.528	1.0			(250)
$C_7H_{14}O$	Dipropyl ketone	20–140	2.310	0.5			(152)
$C_7H_{14}O_2$	Heptylic acid	9	2.335	0.5			(105)
$C_7H_{14}O_2$	Isoamyl acetate	20	1.921	0.5	2.76	0–110	(265)
$C_7H_{14}O_2$	Butyl propionate	20	1.921	0.5			(265)
$C_7H_{14}O_2$	Ethyl valerate	20	1.921	0.5			(266)
$C_7H_{14}O_2$	Propyl butyrate	20	1.921	0.5			(265)
$C_7H_{14}O_2$	Propyl isobutyrate	20	1.921	0.5			(265)
C_7H_{16}	*n*-Heptane (B. P., 98°)	0–50	2.122	0.4			(163)
		20	2.051	0.5			(301)
		30	2.168	0.2	5.94	30–80	(321)
C_7H_{16}	Isoheptane (B. P., 91°)	0–50	2.097	0.4			(163)
$C_8H_6Cl_4$	*o*-Xylene tetrachloride	15–40	1.004	1.0			(61)
$C_8H_6Cl_4$	*p*-Xylene tetrachloride	15–40	1.013	1.0			(61)
$C_8H_8Br_2$	*o*-Xylene dibromide	15–40	0.766	1.0			(61)
$C_8H_8Br_2$	*m*-Xylene dibromide	15–40	0.770	1.0			(61)
$C_8H_8Br_2$	*p*-Xylene dibromide	15–40	0.753	1.0			(61)
$C_8H_8Cl_2$	*o*-Xylene dichloride	15–40	1.184	1.0			(61)
$C_8H_8Cl_2$	*m*-Xylene dichloride	15–40	1.235	1.0			(61)
$C_8H_8Cl_2$	*p*-Xylene dichloride	15–40	1.180	1.0			(61)
C_8H_8O	Acetophenone	20–196	1.984	0.5			(153)
$C_8H_8O_2$	*o*-Toluic acid	0	(1.766)	1.0	3.1	M. P. to 304	(4)
$C_8H_8O_2$	*m*-Toluic acid	0	(2.107)	1.0	1.72	M. P. to 279	(4)
$C_8H_8O_2$	*p*-Toluic acid	0	(1.324)	1.0	5.8	M. P. to 405	(4)
$C_8H_8O_2$	Methyl benzoate	0	1.519	0.5	3.14	10–140	(266)
$C_8H_9O_2$	Hydroxyacetanilide	0	(1.654)	1.0	3.32	M. P. to 231	(4)
C_8H_{10}	Ethylbenzene	0	1.645	0.5			(265)
		30	1.711	0.2	3.71	20–70	(321)
C_8H_{10}	*o*-Xylene	39.6	1.883	0.5			(139)
		30	1.721	0.2	3.24	30–80	(321)
		0	1.605	0.5	4.36	10–110	(266)
C_8H_{10}	*m*-Xylene	9–40	1.674	0.5			(139)
		16–35	1.620	0.5			(139)

Formula	Name	t or Δt, °C	c_p, joule/g	± %	10^3a	Range, °C	Lit.
C_8H_{10}	*m*-Xylene (*Cont'd*)	30	1.678	0.2	3.40	30–80	(321)
C_8H_{10}	*p*-Xylene	0	1.603	0.5	4.36	10–110	(266)
		40.8	1.791	0.5			(139)
		30	1.663	0.2	3.89	10–140	(321)
$C_8H_{10}O$	*p*-Cresyl methyl ether	0	1.697	0.5	3.60	10–140	(266)
$C_8H_{10}O$	Phenetole	20	1.867	0.5	3.60	10–140	(266)
$C_8H_{10}O_4$	Diallyl oxalate	20	1.783	0.5	2.76	10–140	(266)
$C_8H_{11}N$	Dimethylaniline	0–20	1.749	0.5			(45)
		0	1.695	0.1	3.85	20–100	(142, 250, 266)
$C_8H_{14}O_2$	Allyl valerate	20	1.887	0.5	3.68	0–140	(266)
$C_8H_{14}O_4$	Diethyl succinate	20	1.892	0.5	2.76	0–140	(266)
$C_8H_{14}O_4$	Di-*n*-propyl oxalate	20	1.812	0.5	2.76	0–140	(266)
$C_8H_{14}O_5$	Diethyl malate	24–186	1.989	0.5			(152)
C_8H_{16}	Octylene	0–50	2.034	0.4			(163)
$C_8H_{16}O$	Methyl hexyl ketone	22–168	2.311	0.5			(152)
$C_8H_{16}O_2$	Isoamyl propionate	20	1.921	0.5			(265)
$C_8H_{16}O_2$	Butyl butyrate	20	1.921	0.5			(265)
$C_8H_{16}O_2$	Isobutyl butyrate	20	1.921	0.5			(265)
$C_8H_{16}O_2$	Propyl valerate	20	1.921	0.5			(265)
C_8H_{18}	*n*-Octane	0–50	2.113	0.4			(163)
		20–123	2.420	0.5			(152)
$C_8H_{19}N$	Diisobutylamine	22–130	2.390	0.5			(133)
$C_8H_{20}SiO_4$?	Ethyl silicate	15–98	1.783	0.5			(206)
C_9H_7N	Quinoline	0–20	1.473	0.5			(45)
C_9H_{10}	Benzylethylene	0	1.644	0.5	4.36	0–140	(266)
$C_9H_{10}O_2$	Ethyl benzoate	20	1.628	0.5	3.14	0–140	(266)
C_9H_{12}	Mesitylene	0	1.643	0.5	4.36	10–80	(266)
C_9H_{12}	Propylbenzene	0	1.674	0.5	4.365	6–60	(265)
C_9H_{12}	Pseudocumene	20	1.733	0.5	4.35		(266)
$C_9H_{12}O$	Ethyl *p*-cresyl ether	0	1.795	0.5	3.60		(266)
$C_9H_{12}O$	Propyl phenyl ether	0	1.795	0.5	3.60	10–140	(266)
$C_9H_{13}N$	Dimethyl-*o*-toluidine	21–185	2.072	0.5			(155)
$C_9H_{16}O_4$	Dipropyl malonate	20	1.812	0.5	2.76		(266)
C_9H_{18}	Nonylene	0–50	2.030	0.4			(163)
$C_9H_{18}O_2$	Isoamyl butyrate	20	1.921	0.5			(265)
$C_9H_{18}O_2$	Butyl valerate	20	1.921	0.5			(265)
$C_9H_{18}O_2$	Isoamyl isobutyrate	20	1.921	0.5			(265)
C_9H_{20}	Nonane	0–50	2.105	0.4			(163)
$C_{10}H_7NO_2$	α-Nitronaphthalene	58.6	1.528	0.5			(55)
		61.4	1.581	0.5			(55)
		94.3	1.632	0.5			(267)
$C_{10}H_8$	Naphthalene	87.5	1.684	1.0			(20)
		0	(1.310)	1.0	3.52	M. P. to 280	(4)
$C_{10}H_8O$	α-Naphthol	0	(1.626)	1.0	3.19	M. P. to 275	(4)
$C_{10}H_8O$	β-Naphthol	0	(1.688)	1.0	2.61	M. P. to 236	(4)
$C_{10}H_9N$	α-Naphthylamine	53.2	1.988	0.5			(55)
		94.2	1.992	0.5			(267)
$C_{10}H_{10}$	Dihydronaphthalene	18–28	1.448				(258)
$C_{10}H_{10}O_2$	Allyl benzoate	20	1.624	0.5	3.14	10–140	(266)
$C_{10}H_{12}$	1, 2, 3, 4-Tetrahydronaphthalene	15–18	1.687	0.5			(119)
$C_{10}H_{12}O$	Anethole	23–233	2.139	0.5			(157)
		22.48	2.306	0.5			(191)
		24.59	2.360	0.5			(191)
		25.23	2.561	0.5			(191)
$C_{10}H_{12}O_2$	Propyl benzoate	20	1.666	0.5	3.14	0–140	(265)
$C_{10}H_{14}$	*o*-Cymene	0	1.674	0.5	4.36	10–140	(265)
$C_{10}H_{14}O$	Carvacrol	24–233	2.415	0.5			(156)
$C_{10}H_{14}O$	*m*-Thymol	50	2.371	0.5			(19)
$C_{10}H_{14}O$	2, 4-Xylyl ethyl ether	0	1.745	0.5	3.60	10–140	(266)
$C_{10}H_{14}O_4$	Diallyl succinate	20	1.892	0.5	2.76	10–140	(266)
$C_{10}H_{15}N$	Diethylaniline	20	1.892	0.5	3.85	10–140	(266)
$C_{10}H_{18}$	*cis*-Decahydronaphthalene	15–18	1.653	0.5			(119)
$C_{10}H_{18}O_4$	Dibutyl oxalate	20	1.846	0.5			(266)
$C_{10}H_{18}O_4$	Dipropyl succinate	20	1.892	0.5	2.76	10–140	(266)
$C_{10}H_{20}$	Diamylene	20–130	2.281	0.5			(29)

Formula	Name	t or Δt, °C	c_p, joule/g	± %	10^3a	Range, °C	Lit.
$C_{10}H_{20}$	γ-Decylene	0–50	1.963	0.4			(163)
$C_{10}H_{20}O_2$	Isoamyl valerate	20	1.921	0.5			(265)
$C_{10}H_{22}$	Decane (B. P., 159°)	21–154	2.470	0.5			(152)
$C_{10}H_{22}$	Decane (B. P., 162°)	0–50	2.072	0.4			(163)
$C_{10}H_{22}$	Decane (B. P., 172°)	0–50	2.101	0.4			(163)
$C_{10}H_{22}$	Diisoamyl	21.5–155	2.469	0.5			(152)
$C_{11}H_{22}$	Undecylene	0–50	2.017	0.4			(163)
$C_{11}H_{24}$	Undecane	0–50	2.097	0.4			(163)
$C_{12}H_{10}O$	Diphenyl oxide	30	1.67				(73)
$C_{12}H_{11}N$	Diphenylamine	54	1.835	0.4			(55)
		56	1.851	0.4			(55)
		53	1.942	1.0			(20)
		66	2.017	1.0			(20)
$C_{12}H_{12}$	β-Dimethylnaphthalene	0	1.649	0.5			(257)
$C_{12}H_{22}O_4$	Diisoamyl oxalate	20	1.879	0.5			(266)
$C_{12}H_{22}O_4$	Isobutyl succinate	0	1.850	0.5	2.76	0–140	(265)
$C_{12}H_{24}$	Dodecylene	0–50	1.913	0.4			(163)
$C_{12}H_{24}O_2$	Lauric acid	40–100	2.394	0.5			(105)
		57	2.155	0.5			(177)
		14–20	2.120	0.5			(16)
$C_{12}H_{26}$	Dodecane	0–50	2.093	0.4			(163)
		3–40	1.601	0.5			(195)
$C_{13}H_{10}O$	β-Benzophenone	0	1.448	0.5	6.49	0–40	(195)
$C_{13}H_{10}O_3$	Salol	44.1	1.635	0.5			(55)
$C_{13}H_{26}$	Tridecylene	0–50	1.913	0.4			(163)
$C_{13}H_{28}$	Tridecane	0–50	2.088	0.4			(163)
$C_{14}H_{26}O_4$	Isoamyl succinate	0	1.880	0.5			(262)
$C_{14}H_{28}$	Tetradecylene	0–50	1.896	0.4			(163)
$C_{14}H_{28}O_2$	Myristic acid	56–100	2.256	0.5			(285)
$C_{14}H_{30}$	Tetradecane	0–50	2.080	0.4			(163)
$C_{15}H_{30}$	Pentadecylene	0–50	1.971	0.4			(163)
$C_{15}H_{32}$	Pentadecane	0–50	2.080	0.4			(163)
$C_{16}H_{32}O_2$	Palmitic acid	65–104	2.733	0.5			(105)
$C_{16}H_{34}$	*n*-Hexadecane (B. P., 275°)	0–50	2.076	0.4			(163)
$C_{17}H_{12}O_3$	Betol	19–63	1.487	0.2			(195)
		0	(1.249)	0.2	5.58*	19–63	(195)
$C_{18}H_{36}O_2$	Stearic acid	75–137	2.302	0.5			(105)

* $10^4b = 5.61$.

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THE HEAT CAPACITY OF CERTAIN PURE LIQUIDS

J. H. AWBERY

Hg, Mercury

Solid Hg (13, 69, 83, 138, 209, 235, 236, 243, 282)			Liquid Hg (10, 12, 18, 43, 48, 58, 123, 138, 186, 235, 236, 262, 322)					
t, °C	Joule/g-atom	± %	t, °C	Joule/g	± %	t, °C	Joule/g ±0.1 %	
−270	0.221	1	−40	0.1452	0.1	120	0.1374$_5$	
−260	4.61	2	−20	0.1417	0.1	140	0.1374$_2$	
−240	16.95	0.5	0	0.14030	0.25	160	0.1374$_8$	
−220	21.27	0.5	+20	0.13934	0.25	180	0.1376$_0$	
−200	23.07	0.5	40	0.13864	0.25	200	0.1377$_7$	
−150	25.76	0.5	60	0.13814	0.25	220	0.1379$_7$	
−100	26.92	0.5	80	0.13780	0.25	240	0.1382$_4$	
− 50	27.77	0.5	100	0.1375$_7$	0.1	260	0.1385$_1$	
− 40	27.99	0.5				280	0.1388$_0$	

H_2O, Water

c_p in joules per gram. NOTE.—The values in this table should be increased by 0.12 % to bring them into accord with the I. C. T. accepted value for the joule which is 4.185 cal.

t, °C	p = 1 atm. (8, 9, 10, 11, 41, 42, 53, 54, 62, 72, 99, 101, 102, 104, 126, 127, 150, 214, 242, 259)					p = the vapor pressure (72, 104, 242)		
	c_p	± %	°C	c_p	± %	°C	c_p	± %
−5	4.244	0.2	20	4.184	0.05	100	4.198	0.2
0	4.220	0.2	40	4.180	0.1	150	4.222	0.2
+5	4.210	0.2	60	4.186	0.1	200	4.255	0.5
10	4.199	0.1	80	4.192	0.2	250	4.30	1.0
15	4.190	0.1	100	4.198	0.2	300	4.35	2.5

CO_2

Liquid; values of c_p and c_v, joule/g, p in kg/cm², v in cm³/g

$c_p \pm 5\%$ (67, 130, 162)						$c_v \pm 2\%$ (7, 71)					
t, °C \ p	40	65	t, °C \ p	65	90	115	t, °C \ v	1.1	t, °C \ v	2.66	t, °C \ v	2.66
−50		1.94	0	2.15	2.08	2.00	0	1.00	30	5.08	80	5.74
−40		2.00	+10	2.3	2.17	2.07	10	1.00	40	5.19	90	5.91
−30		2.07	20	2.8	2.50	2.3	20	1.04	50	5.31	100	6.16
−20	2.0	2.17	25	3.6	2.8	2.55	30	1.19	60	5.45	110	6.57
−10	2.1	2.25	30		3.3	2.8	40	1.29	70	5.59	120	7.26

VARIATION OF SPECIFIC HEAT WITH PRESSURE

Values of (specific heat at 1 atm. − sp. ht. at p, kg/cm²) ± 1%; joules per gram

Hg, Mercury (47, 158)

p, kg/cm²	15°	64°	91°	p, kg/cm²	15°	p, kg/cm²	15°
0	0.0	0.0	0.0	1000	0.000062	5000	0.000246
200	0.00002	0.00046	0.00059	2000	0.000092	6000	0.000277
400	0.00005	0.00105	0.00129	3000	0.000154	7000	0.000338
600	0.00005	0.00146	0.00207	4000	0.000185		

CS_2, CH_3OH and C_2H_5OH (47, 158)

p, kg/cm²	CS_2				CH_3OH				C_2H_5OH			
	20°	40°	60°	80°	20°	40°	60°	80°	20°	40°	60°	80°
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
500						+0.002	0.0					
1 000	−0.00043	+0.0022	+0.0078	+0.0170	+0.006	+0.008	+0.011	+0.012	−0.001	+0.004	+0.006	+0.006
2 000	−0.0078	+0.0004	+0.0100	+0.0310	+0.014	+0.011	+0.019	+0.026	−0.001	+0.008	+0.010	+0.004
3 000	−0.0091	−0.0019	+0.0095	+0.0378	−0.007	+0.008	+0.021	+0.026	−0.001	+0.013	+0.011	+0.001
4 000	−0.0061	−0.0013	+0.0077	+0.0382	−0.009	+0.006	+0.017	+0.023	−0.000	+0.014	+0.009	−0.001
5 000	−0.00174	−0.0022	+0.0062	+0.0313	−0.010	+0.004	+0.016	+0.018	+0.001	+0.011	+0.004	−0.003
6 000	+0.0052	−0.0044	+0.0054	+0.0205	−0.011	+0.003	+0.013	+0.016	+0.003	+0.008	+0.001	−0.003
7 000	+0.0118	−0.0074	+0.0017	+0.0144	−0.011	−0.003	+0.009	+0.017	+0.002	+0.004	−0.001	−0.001
8 000	+0.0104	−0.0096	−0.0017	+0.0131	−0.012	−0.007	+0.003	+0.023	+0.001	+0.001	−0.006	+0.004
9 000	+0.0035	−0.0135	−0.0039	+0.0162	−0.012	−0.011	−0.003	+0.033	−0.003	−0.009	−0.009	+0.031
10 000	−0.0022	−0.0214	−0.0050	+0.0220	−0.015	−0.014	−0.004	+0.051	−0.011	−0.013	−0.012	+0.057
11 000	−0.0017	−0.0264	−0.0065	+0.0229	−0.020	−0.015	−0.001	+0.059	−0.018	−0.013	−0.012	+0.055
12 000	+0.0017	−0.0245	−0.0078	+0.0112	−0.013	−0.013	+0.001	+0.035	−0.000	−0.013	−0.011	+0.003

Values of c_p for the Liquid State

p = the vapor pressure

NH_3
(7, 71, 74, 79, 135, 149, 210, 288)

t, °C	c_p, joule/g	± %
−60	4.383	0.1
−40	4.440	
−20	4.510	
0	4.597	
+ 20	4.710	
40	4.860	
60	5.084	
80	5.42	0.25
90	5.71	
100	6.19	0.5
110	6.72	1

v. also p. 86.

SO_2
(56, 175, 232)

−20	1.31	5
0	1.33	
+20	1.37	
40	1.43	

SO_2.—(*Continued*)

t, °C	c_p, joule/g	± %
60	1.51	
80	1.62	
100	1.75	
120	1.95	
140	2.38	(179)
150	3.54	
11 to 140	1.37 + 0.0012t	0.5

H_2SO_4
(56, 175, 227, 228, 232)

10 to 45	1.42 + 0.0016t	3

C_2H_5OH, Ethyl alcohol
(2, 21, 36, 40, 95, 111, 116, 122, 152, 187, 243, 247, 249, 273, 289, 301, 321)

−100	1.91	0.5
− 75	1.92	

C_2H_5OH.—(*Continued*)

t, °C	c_p, joule/g	± %
− 50	1.98	
0	2.24	
+ 25	2.43	1
50	2.73	
100	3.45	3
150	4.41	

p = 1 atm.

CH_3OH, Methyl alcohol
(40, 111, 139, 144, 275, 301)

0	2.37	1
20	2.51	
40	2.58	

C_3H_7OH, Propyl alcohol
Normal (40, 95, 139, 152, 187, 247, 301)

−120	1.80	1
−100	1.82	
− 50	1.91	
− 25	2.01	
0	2.20	
+ 25	2.45	
50	2.74	

C_3H_7OH.—(*Continued*)
Iso- (152, 187, 219, 321)

t, °C	c_p, joule/g	± %
−100	1.78	3
− 50	1.98	
0	2.36	
+ 50	3.10	

CS_2, Carbon disulfide
(21, 89, 111, 122, 138, 289)

−100 to +150	0.984 + 0.0010$3t$	6 at extremes, 3 at 0

$C_2H_4O_2$, Acetic acid
(23, 28, 105, 148, 153, 176, 178, 192, 219, 249, 265, 301)

0 to 80	1.960 + 0.0038$9t$	2

$C_3H_8O_3$, Glycerol
(28, 80, 93, 166, 282, 283)
Liquid and vitreous

−260	0.18	5
−200	0.46	
−150	0.73	2

$C_3H_8O_3$.—(*Continued*)

t, °C	c_p, joule/g	± %
−100	0.97	
− 95	1.00	
?U		
− 85	1.89	
− 50	2.03	
0	2.26	
+ 50	2.51	5
100	2.80	

C_6H_6, Benzene
(4, 23, 65, 89, 116, 182, 232, 247, 265, 267, 275, 301, 302, 321)

t, °C	c_p, joule/g	± %
5	1.63	2
10	1.65	
20	1.70	
40	1.77	
60	1.86	

C_6H_6.—(*Continued*)

t, °C	c_p, joule/g	± %
80	1.94	
90	1.98	

C_7H_8, Toluene
(21, 23, 81, 89, 116, 224, 249, 265, 281, 301, 302, 321)

−97	1.472	1
−50	1.522	
0	1.614	
+50	1.761	

C_7H_8.—(*Continued*)

t, °C	c_p, joule/g	± %
80	1.869	
100	1.966	

C_6H_7N, Aniline*
(15, 92, 100, 111, 139, 156, 224, 231, 266, 267, 301)

0	2.00	5
50	2.18	
100	2.29	

*For more recent data, *v.* (324).

LITERATURE, *v.* p. 116.

THE HEAT CAPACITY OF CERTAIN SOLUTIONS

J. H. Awbery

AQUEOUS SOLUTIONS

Acids

(M = Mole)

HCl (57, 176, 251, 252, 253, 295, 296, 304, 309)

M % HCl	M_{HCl}/M_{H_2O}	Joule/g ±¼% 0°C	10°C	20°C	40°C	60°C
0.0	0.0	4.215	4.195	4.182	4.174	4.182
4.76	.05	3.446	3.446	3.521	3.532	3.265
9.09	.10	3.015	3.015	3.132	3.141	3.272
13.0	.15	2.743	2.714	2.852	2.879	2.974
16.7	.20	2.560	2.526	2.643	2.701	2.798
20.0	.25	2.430	2.413	2.476	2.576	2.677
23.1	.30	2.346	2.338	2.350	2.488	2.605
25.9	.35	2.300				2.551

H_2SO_4 (35, 56, 111, 175, 221, 232, 233, 268)

M % H_2SO_4	$M_{H_2O}/M_{H_2SO_4}$	Joule/g ±¼%, 18°C	±½%, 35°C	M % H_2SO_4	$M_{H_2O}/M_{H_2SO_4}$	Joule/g ±¼%, 18°C
100.0	0	1.397	1.414	0.99	100	4.002
16.7	5	2.417	2.242	0.66	150	4.048
9.09	10	2.999	2.59	0.497	200	4.077
4.76	20	3.467	2.97	0.0	∞	4.182
3.23	30	3.663	3.26			
2.44	40	3.780	3.43			
1.96	50	3.860	3.53			
1.64	60	3.911	3.60			

$C_2H_4O_2$, Acetic acid, 38°C (176, 235, 249)

M % HAc	0.0	3.23	6.98	16.7	30.9	54.5	100.0
Joule/g	4.17	4.01	3.81	3.44	3.05	2.64	2.24

Alkalies

NH_3 (295, 309)

M % NH_3	M_{NH_3}/M_{H_2O}	Joule/g ±½% 2.4°C	20.6°C	41°C	61°C
0.0	0	4.211	4.182	4.174	4.182
5.2	5	4.148	4.186	3.998	4.216
10.5	10	4.098	4.170	4.441	4.261
15.8	15	4.073	4.144	4.354	4.303
20.9	20	4.023	4.144	4.308	
26.1	25	4.006	4.165		
31.2	30	4.002	4.197		
36.3	35	4.023	4.236		
41.4	40	4.124			

$C_6H_5NH_2$, Aniline, 20°C (15, 165)

M % $PhNH_2$	100	95.0	90.5	82.3	75.2
Joule/g ±2%	2.08	2.17	2.22	2.34	2.43

NaOH, 20°C (36, 110, 251, 252, 295, 296, 304)

M % NaOH	0.0	0.50	0.99	4.76	9.09
Joule/g ±0.1%	4.182	4.123	4.045	3.701	3.498

M % NaOH	16.7	23.1	28.6	37.5
Joule/g ±0.1%	3.341	3.287	3.275	3.270

KOH (110, 251, 252, 295, 296)

M % KOH	Joule/g ±0.1%, 19°C	±0.5%, 27°C	M % KOH	Joule/g ±0.1%, 19°C	M % KOH	Joule/g ±0.1%, 19°C
9.09	3.132	3.26	1.64	3.894	0.497	4.077
4.76	3.396	3.51	1.23	3.956	0.333	4.094
2.44	3.764	3.81	0.99	3.998	0.249	4.103
					0.0	4.182

Salts

NaCl (43, 66, 103, 176, 239, 252, 273, 294, 295, 322)

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M % NaCl	M_{H_2O}/M_{NaCl}	Joule/g ±0.1% 6°C	20°C	33°C	57°C
9.09	10	3.37	3.38	3.39	3.41
6.25	15	3.457	3.468	3.472	3.52
4.76	20	3.572	3.593	3.604	3.64
2.44	40	3.809	3.822	3.834	3.86
1.64	60	3.910	3.922	3.934	
1.23	80	3.969	3.980	3.988	
0.99	100	4.011	4.020	4.021	
0.66	150	4.054	4.062	4.068	
0.497	200	4.092	4.092	4.093	
0.333	300		4.113		
0.249	400		4.14		

t, °C	d_4^t	Joule/g ±1%	Lit.
−15	1.114	3.20	(69)
−25	1.26	2.71	

KCl (43, 128, 176, 181, 239, 252, 273, 294, 295, 296, 322)

M % KCl	M_{KCl}/M_{H_2O}	Joule/g ±0.1% 6°C	20°C	33°C	40°C
0.0	0.0	4.202	4.180	4.170	4.17
0.99	0.01	3.954	3.958	3.962	3.96
1.96	0.02	3.771	3.772	3.788	3.78
2.91	0.03	3.611	3.622	3.633	3.64
3.85	0.04	3.461	3.478	3.492	3.50
4.76	0.05	3.337	3.351	3.367	3.35
5.66	0.06	3.222	3.238	3.254	3.24
6.54	0.07	3.12	3.138	3.16	3.13
7.41	0.08		3.036		

ALCOHOLS

B = CH_3OH, Methyl alcohol (40, 144)

M % B	Joule/g ±¼%			M % B	Joule/g ±¼%		
	5°	20°	40°		5°	20°	40°
0.0	4.184	4.182	4.176	36.0	3.454	3.626	3.668
2.87	4.270	4.195	4.170	45.8	3.245	3.387	3.471
5.88	4.253	4.186	4.163	56.7	3.045	3.166	3.266
9.03	4.174	4.157	4.136	69.6	2.852	2.957	3.040
12.3	4.077	4.113	4.107	83.5	2.643	2.727	2.831
19.4	3.872	4.015	4.015	100.0	2.413	2.509	2.580
27.3	3.668	3.835	3.856				

B = C_2H_5OH, Ethyl alcohol (36, 40, 52, 164, 165, 273, 323)

M % B	Joule/g		
	±0.5%, 3°C	±0.5%, 23°C	±1%, 41°C
0.0	4.211	4.182	4.174
2.02	4.316	4.236	4.241
4.16	4.379	4.274	4.291
6.46	4.395	4.312	4.320
8.91	4.362	4.324	4.324
11.5	4.282	4.299	4.299
14.4	4.186	4.241	4.257
20.7	3.925	4.077	4.107
28.1	3.622	3.847	3.898
37.0	3.367	3.588	3.655
47.7	3.132	3.329	3.404
61.0	2.802	3.040	3.132
77.9	2.568	2.760	2.861
100.0	2.263	2.417	2.601

B = C_3H_7OH, *n*-Propyl alcohol (40, 213)

M % B	Joule/g ±¼%			M % B	Joule/g ±¼%		
	5°	20°	40°		5°	20°	40°
0.0	4.203	4.182	4.174	16.7	3.990	4.044	3.986
1.55	4.308	4.282	4.231	23.1	3.668	3.772	3.810
3.23	4.395	4.383	4.280	31.0	3.404	3.521	3.617
5.03	4.466	4.441	4.312	41.2	3.128	3.254	3.408
6.97	4.538	4.466	4.320	54.5	2.852	2.973	3.203
9.09	4.517	4.441	4.253	73.0	2.559	2.695	2.961
11.4	4.329	4.329	4.165	100.0	2.233	2.384	2.601

B = $C_3H_8O_3$, Glycerol (35, 80, 166)

M % B	Joule/g ±½%		M % B	Joule/g ±½%	
	15°C	32°C		15°C	32°C
0.0	4.18	4.17	22.7	3.20	3.17
2.12	4.03	4.02	43.9	2.80	2.81
4.66	3.88	3.86	100.0	2.32	2.41
11.5	3.56	3.52			

NON-AQUEOUS SOLUTIONS

c_p = joule/g

CS_2

B = CH_4O
±3% (52)
t = 20°C

M % A	c_p
100.0	1.02
55.8	1.51
29.5	1.97
12.3	2.26
0.0	2.51

CH_4O

B = C_2H_6O
±0.5% (40)
t = 25°C

M % A	c_p
100.0	2.530
85.2	2.518
68.3	2.501
48.9	2.493
26.4	2.467
0.0	2.430

B = C_3H_8O

n-Propyl alcohol
±0.5% (139)
t = 40°C

M % A	c_p
100.0	2.580
81.7	2.526
65.2	2.530
38.5	2.559
0.0	2.601

C_2H_6O

B = C_3H_8O
n-Propyl alcohol
Solid, ±2% (95)
50 M % A

°C	c_p
−200	0.92
−190	1.02
−180	1.11
Liquid, ±0.5%	
−75	1.865
−50	2.003
−25	2.112
0	2.196

B = C_6H_6
±0.5% (223, 307)
t = 20°C

M % A	c_p
0.0	1.70
15.8	1.80
29.8	1.92
42.1	2.03
53.0	2.11
62.9	2.175
71.8	2.22
79.8	2.26
87.2	2.325
93.8	2.342
100.0	2.405

B = $NaCl.200H_2O$
±1% (136)
t = 20°C

M % A*	c_p
0.0	4.08
89.8	4.20
95.2	4.27
97.2	4.20
98.2	4.03
99.2†	3.51
99.7‡	2.96
100.0	2.38

*M % A = moles C_2H_6O/(moles C_2H_6O + moles salt).
† ±1. ‡ ±2.

B = $KCl.200H_2O$
±1% (136)
t = 58°C

0.0	4.04
89.9	4.18
95.2	4.23
97.2	4.16
98.2	3.98
99.2	3.63
99.7	3.15
100.0	2.84

B = C_6H_7N
Aniline
±0.5% (139)
t = 40°C

0.0	2.13
34.1	2.38
60.8	2.62

B = C_6H_7N.— *(Cont'd)*

M % A	c_p
82.3	2.79
86.1	2.81
93.4	2.81
100.0	2.60

$C_3H_8O_3$
Glycerol
B = C_6H_7N
Aniline
±0.5% (166)
t = 20°C

0.0	2.15
5.1	2.24
10.1	2.31
20.2	2.41
30.2	2.47

$C_4H_{10}O$
Ether
B = C_6H_6, Benzene
±2% (275)

M % A	c_p 6°C	c_p 20°C
100	2.24	2.36
75	2.18	2.30
50	2.10	2.21
25	1.99	2.07
0	1.69	1.77

LITERATURE

(For a key to the periodicals see end of volume)

(1) Abt, *527*, **1896**: 42. (2) Andrews, *4*, **1**: 27; 49. (3) Andrews, *1*, **48**: 1287; 26. (4) Andrews, Lynn and Johnston, *1*, **48**: 1274; 26. (5) Armstrong, *325*, **19**: 393; 08. (6) Auerbach, *7*, **121**: 337; 26. (7) Babcock, *65*, **55**: 327; 20. (8) Barnes, *5*, **67**: 238; 00. (9) Barnes, *62*, **199**: 149; 02.
(10) Barnes, *69*, **3 III**: 3; 09. *133*, **1909**: 403. (11) Barnes and Cooke, *2*, **15**: 65; 02. (12) Barnes and Cooke, *133*, **1902**: 530. *2*, **16**: 65; 03. (13) Barschall, *9*, **17**: 341; 11. (14) Bartoli, *Bull. Mensile della Accad. Gioenia*, **17**: 4; 91. (15) Bartoli, *72*, **28**: 1032; 95. *59*, **2**: 347; 95. (16) Bartoli and Stracciati, *170*, **19**: 643; 84. *59*, **15**: 5; 84. (17) Bartoli and Stracciati, *427*, **15**: 761; 91. (18) Bartoli and Stracciati, *72*, **28**: 469; 95. (19) Barus, *8*, **33**: 431; 92.
(20) Battelli, *24*, **3**: 1781; 84. (21) Battelli, *22*, **16 I**: 243; 07. *59*, **13**: 418; 07. (22) Baud, *51*, **2**: 569; 03. (23) Baud, *6*, **27**: 89; 12. (24) Bellati and Lussana, *24*, **7**: 1051; 88. (25) Bellati and Romanese, *24*, **6**: 1043; 83. *5*, **34**: 104; 83. (26) Berthelot, *6*, **12**: 529; 77. (27) Berthelot, *34*, **85**: 646; 77. *6*, **12**: 550; 77. (28) Berthelot, *34*, **86**: 786; 78. *6*, **15**: 242; 78. (29) Berthelot, *34*, **89**: 119; 79.
(30) Berthelot, *6*, **17**: 137; 79. (31) Berthelot, *34*, **93**: 291; 81. (32) Berthelot, *6*, **27**: 389; 82. (33) Berthelot and Ogier, *34*, **92**: 669; 81. *6*, **23**: 201; 81. (34) Bichowsky, *1*, **45**: 2225; 23. (35) Blümcke, *8*, **24**: 263; 85. (36) Blümcke, *8*, **25**: 154, 417; 85. (37) Bogojawlensky, *322*, **1904**: 1. (38) Bogojawlensky and Winogradow, *7*, **24**: 251; 08. (39) Bornemann and Hengstenberg, *187*, **17**: 313; 20.
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(60) Cohn, *38*, **7**: 475; 24. (61) Colson, *34*, **104**: 428; 87. (62) Cotty, *6*, **24**: 282; 11. (63) Dana, Jenkins, Burdick and Tim, *332*, **12**: 387; 26. (64)

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(120) Hess, *8*, **35**: 410; 88. (121) Hildebrand, Duschak, Foster and Beebe, *1*, **39**: 2293; 17. (122) Hirn, *6*, **10**: 32; 67. (123) Hirobe, *41*, **32**: 558; 11. (124) Holsboer, *B85*, p. 307. (125) Jackson, *1*, **34**: 1470; 12. (126) Jaeger and Steinwehr, *8*, **64**: 305; 21. (127) Janke, *Diss.*, Rostock, 1910. (128) Jaquerod, *Thesis*, Geneva, 1901. (129) Jenkin and Pye, *62*, **213**: 67; 13.
(130) Jenkin and Shorthose, *5*, **99**: 352; 21. (131) Jenkin and Shorthose, *B67*. (132) Joly, *5*, **41**: 250; 86. (133) Kahlenberg, *50*, **5**: 284; 01. (134) Kahlenberg and Koenig, *50*, **12**: 290; 08. (135) Keyes and Babcock, *1*, **39**: 1524; 17. (136) Kolosovskii, *7*, **81**: 713; 13. (137) Kopp, *62*, **155**: 71; 65. (138) Koref, *8*, **36**: 49; 11. (139) Kremann, Meingast and Gugl, *57*, **35**: 1235; 14.
(140) Kroeker, *190*, **1892 II**: 125. *188*, **1892**: 122. (141) Lange, *7*, **110**: 343; 24. (142) Lascenko, *53*, **42**: 1604; 10. (143) Latimer, *1*, **44**: 90; 22. (144) Lecher, *75*, **76 II**: 937; 78. (145) Lindemann, *88*, **13**: 1107; 11. *76*, **1911**: 316. (146) Lindemann and Schwers, *63*, **14**: 766; 13. (147) Lindner, *Diss.*, Erlangen, 1903. (148) Luedeking, *8*, **27**: 72; 86. (149) Luedeking and Starr, *12*, **45**: 200; 93.
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(170) Magnus, *63*, **14**: 5; 13. (171) Magnus, *8*, **70**: 303; 23. (172) Magnus and Dans, *8*, **31**: 407; 26. (173) Maier, Parks and Anderson, *1*, **48**: 2564; 26. (174) Maier and Ralston, *1*, **48**: 364; 26. (175) Marignac, *149*, **39**: 217; 70. *13*, **8 Suppl.**: 335; 72. (176) Marignac, *6*, **8**: 410; 76. (177) Massol and Faucon, *34*, **154**: 268; 11. (178) Massol and Guillot, *34*, **121**: 208; 95. (179) Mathias, *51*, **5**: 381; 96.
(180) Meyer, *Thesis*, Paris, 1912. (181) Mie, *8*, **33**: 381; 10. (182) Mills and MacRae, *50*, **14**: 797; 10. **15**: 54; 11. (183) Milthaler, *8*, **36**: 897; 89. (184) Mitchell, *4*, **123**: 1055; 23. (185) Müller, *25*, **16**: 214; 84. (186) Naccari, *51*, **8**: 612; 89. (187) Nadejdin, *53*, **16**: 222; 84. (188) Narbutt, *9*, **24**: 339, 342; 18. *322*, No. **23**; 16. (189) Narbutt, *9*, **25**: 51; 19.
(190) Narbutt, *9*, **26**: 203; 20. (191) Nasini and Bresciani, *59*, **6**: 437; 13. (192) Nasini and Bresciani, *170*, **9**: 342; 13. (193) Nernst, *76*, **1910**: 262. (194) Nernst, *76*, **1911**: 306. *8*, **36**: 395; 11. *9*, **17**: 265; 11. (195) Nernst, Korff and Lindemann, *76*, **1910**: 247. (196) Nernst and Lindemann, *76*, **1911**: 494. (197) Nernst and Lindemann, *76*, **1912**: 1160. (198) Nernst and Schwers, *76*, **1914**: 355. (199) Neumann, *8*, **126**: 123; 65.
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(210) Osborne and Van Dusen, *365*, No. **142**: 23. (211) Padoa, *22*, **29**: 198; 20. (212) Pagliani, *23*, **17**: 97; 81. (213) Pagliani, *59*, **12**: 229; 82. (214) Pagliani, *59*, **8**: 157; 14. (215) Palmaer, *9*, **29**: 415; 23. (216) Pape, *8*, **120**: 336; 63. (217) Pape, *8*, **122**: 408; 64. (218) Parks, *1*, **47**: 338; 25. (219) Parks and Kelley, *1*, **47**: 2089; 25.
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(270) Schottky, *7*, **64**: 415; 08. (271) Schottky, *63*, **10**: 634; 09. (272) Schüller, *8*, **136**: 235; 69. (273) Schüller, *8*, **5 Ergänz.**: 116, 192; 71. (274) Schulz, *189*, **1911**: 632. (275) Schulze, *88*, **14**: 189, 258, 344; 12. (276) Schwers, *186*, **1908**: 814. (277) Seibert, Hulett and Taylor, *1*, **39**: 38; 17. (278) Sella, *188*, **38**: 311; 91. (279) Séxton, *83*, **6**: 120; 10.
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THE HEAT CAPACITY OF ALLOYS, AMALGAMS AND INTERMETALLIC COMPOUNDS

LUIGI ROLLA

CONTENTS

Ferrous alloys.
Amalgams.
Non-ferrous alloys.

SYMBOLS

C_p (resp. C_m) True (resp. mean) heat capacity at t, °C (resp. t_1 to t_2, °C), in joules per gram-molecular weight per deg C.

c_p (resp. c_m) True (resp. mean) specific heat at t, °C (resp. t_1 to t_2, °C), in joules per gram per deg C.

ARRANGEMENT

In each part the alloys are arranged in alphabetical order according to the chemical symbols of the elements which they contain. Thus, Cu-Al alloys will be found under Al; but Cu-Sn alloys will be found under Cu, Zn-Sn alloys under Sn, etc.

MATIÈRES

Métaux ferreux.
Amalgames.
Alliages non ferreux.

SYMBOLES

C_p (resp. C_m) Capacité calorifique vraie (resp. moyenne) à t, °C (resp. t_1 à t_2, °C) en joules par poids moléculaire gramme et par degré C.

c_p (resp. c_m) Chaleur spécifique vraie (resp. moyenne) à t, °C (resp. t_1 à t_2, °C) en joules par gramme par degré C.

ARRANGEMENT

Dans chaque partie, les alliages sont arrangés dans l'ordre alphabétique en accord avec les symboles chimiques des éléments qu'ils contiennent. Ainsi les alliages Cu-Al seront trouvés sous Al alors que les alliages Cu-Sn seront trouvés sous Cu et les alliages Zn-Sn sous Sn, etc.

INHALTSVERZEICHNIS

Eisenlegierungen.
Amalgame.
Eisenfreie Legierungen.

ZEICHEN

C_p (bezw. C_m) Wahre (bezw. mittlere) Wärmeinhalt bei t, °C (bezw. t_1 bis t_2, °C) in Joule pro Gramm-Molekulargewicht pro °C.

c_p (bezw. c_m) Wahre (bezw. mittlere) spezifische Wärme bei t, °C (bezw. t_1 bis t_2, °C) in Joule pro Gramm pro °C.

ANORDNUNG

In jedem Teil sind die Legierungen nach dem Alphabet geordnet und zwar nach den chemischen Symbolen der sie zusammensetzenden Elemente. So wird man Cu-Al-Legierungen bei Al finden, aber Cu-Sn-Legierungen bei Cu dann Zn-Sn-Legierungen unter Sn und so fort.

INDICE

Leghe del ferro 118
Amalgame 119
Leghe non contenenti ferro 119

SIMBOLI

C_p (o C_m) Calore specifico vero (o medio) a t, °C (o fra t_1 e t_2, °C) espresso in joule per grammo molecola.

c_p (o c_m) Calore specifico vero (o medio) a t, °C (o fra t_1 e t_2, °C) espresso in joule per grammo.

DISPOSIZIONE

Le leghe sono disposte in ordine alfabetico secondo i simboli chimici degli elementi in esse contenuti. Per esempio, la lega Cu-Al si trova sotto Al; la lega Cu-Sn si trova sotto Cu, la lega Zn-Sn sotto Sn, ecc.

FERROUS ALLOYS

Fe-C

v. also Vol. II, p. 518

$c_m(17\text{–}100°) = 0.4661 + 0.0184 \times$ % C (From 0 to 7 %) (14)

% C	17–250°	0.17	0.35	0.81	1.00	1.43	4.13
c_m (14)		0.4956	0.4985	0.5056	0.5119	0.5215	0.5818
% C	17–400°	0.11	0.45	0.89	1.22	1.54	4.06
c_m (14)		0.5207	0.5249	0.5362	0.5425	0.5445	0.5919
% C	17–500°	0.17	0.45	0.89	1.22	1.54	4.06
c_m (14)		0.5471	0.5475	0.5579	0.5592	0.5617	0.6002
% C	17–550°	0.17		1.54		4.06	
c_m (14)		0.5517		0.5551		0.6019	
% C	17–640°	0.17	0.45	0.89	1.22	1.54	4.06
c_m (14)		0.5747	0.5772	0.5839	0.5856	0.5868	0.6090
% C	17–680°	0.11		0.89	1.00		4.06
c_m (14)		0.5902		0.5969	0.5985		0.6165

0.5 % C; $c_m(-186$ to $+18°) = 0.3570$; $(18\text{–}100°) = 0.4730$ (1). For higher temps., *v.* Fig. 2.

Fe_3C, Cementite (14); Mol. wt. = 179.52

t, °C	100	250	400	525	640	680
c_m (17–$t°$)	106.0	114.4	114.7	114.4	113.5	113.8

0.09 % C; $c = 0.4889$ (tempered from 850°C in H_2O); $= 0.4922$ (annealed 24 hr at 650°C) (10).

% C (10)	0.29	0.50	0.70	0.89	1.05	1.48
c (normalized)	0.4818	0.4872	0.4939	0.4989	0.5039	0.5136
c (annealed)	0.4801	0.4788	0.4885	0.4964		0.5078

Cast iron (annealed m minutes at 670°C) (10)

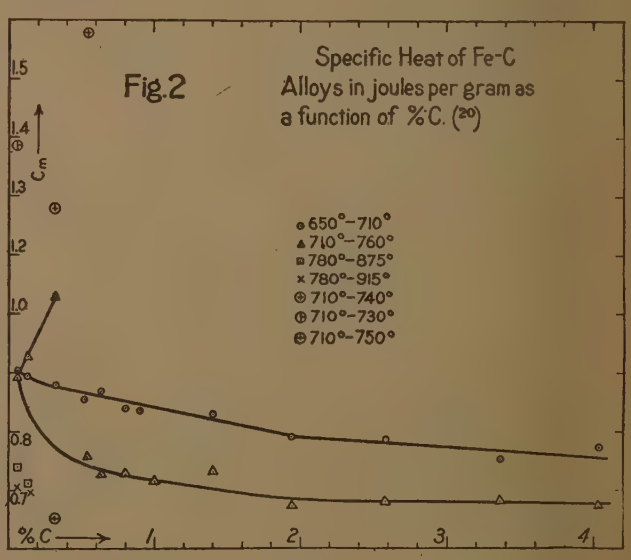
m	0	5	10	60
c	0.5739	0.5630	0.5508	0.4847

Fe-Ni, Ferronickel

30 % Fe; $c_p = 0.4696$ at 100°C (5).

Fe-Sb

55 % Fe; c_m (0–100°) = 0.3637 (12).



Fe-Si

% Fe (23)	90	86	50	25	15	5
c_m (0–41°)	0.543	0.553	0.606	0.655	0.673	0.692

FeSi (34); Mol. wt. = 83.9

t, °C	17–100	100	200	300	400	500	600
C	49.7 (32)	51.5	54.1	56.2	57.9	59.4	60.4

Special Fe Alloys

Fe, 71.6 + Si, 1.7 + V, 26.7; $c_m(15\text{–}100°) = 0.496$ (18)

Invar	$t°$	−182 to −15	15–100	15–600	(36)
	c_m	0.3876	0.5023	0.5274	

C, 1.25 + Mn, 0.62 + Si, 0.46; $c_p(12°) = 0.513$ (3).
C, 0.7 + Mn, 0.82 + Ni, 31.4; $c_p(12°) = 0.506$ (3).
C, 0.6 + Mn, 5.04 + Ni, 25.0; $c_p(12°) = 0.496$ (3).
C, 0.76 + Mn, 0.28 + W, 11.5; $c_p(12°) = 0.436$.
C, 0.26 + Si, 5.50; $c_p(12°) = 0.450$ (3).
C, 1.09 + Cr, 9.50; $c_p(12°) = 0.505$ (3).
C, 0.04 + Al, 1.0 + Cu, 3.75 + Mn, 0.16; $c_p(12°) = 0.491$ (3).

	S	C	Cu	Mn	P	Si	$c_p^{18°} = 0.441$
%	0.025	0.1	0.035	0.11	0.003	0.18	$c_p^{100°} = 0.496$ (11)

Krupp Steel

I. C, 0.01 + Mn, Tr. + P, 0.04 + S, 0.03 + Si, 0.02.
II. C, 0.06 + Mn, 0.05 + P, 0.005 + S, 0.019 + Si, 0.005.

$t°$	250	300	350	400	450	500
$c_I(0–t°)$ (7)	0.504	0.516	0.526	0.537	0.549	0.560
$c_{II}(0–t°)$ (22)	0.511	0.526	0.538	0.546	0.561	0.572
$t°$	550	600	650	700	750	800
$c_I(0–t°)$ (7)	0.570	0.584	0.600	0.622	0.643	0.669
$c_{II}(0–t°)$ (22)	0.584	0.593	0.612	0.667	0.701	0.711
$t°$	850	900	950	1000	1050	1100
$c_I(0–t°)$ (7)	0.689	0.688	0.675	0.652	0.633	0.642
$c_{II}(0–t°)$ (22)	0.711	0.711	0.707	0.702	0.699	0.697

Ferromanganese (21)

C, 0.6 + Mn, 48 + Si, 21.9; $c_m(-185$ to $+20°) = 0.446$.

Ferronickel (9)

C, 0.36 + Ni, 0.24 + Mn, 0.4

$t°$	0–18	20–100	20–270
c_m (magnetic)	0.4546	0.4939	0.5203
c_m (non-magnetic)	0.4274	0.4713	0.5186

AMALGAMS

Formula or Wt. % Hg	t or Δt, °C	c_p or c_m, joule/g	Lit.
	Hg-K		
90.4	−22 to +15	0.1882	(35)
	Hg-Na		
97	−22 to +15	0.2257	(35)
90	−21 to +15	0.1592	
	Hg-Zn		
9.5	0 to 97	0.3765	(17)
20.1		0.3516	(17)
31.2		0.3403	(17)
37.2		0.3641	(17)
49.0		0.3457	(17)
61.2		0.3202	(17)
67.7		0.3055	(17)
79.7		0.2829	(17)
88.6		0.2683	(17)
HgZn	−27 to +15	0.2314	(35)
HgZn	15 to 89	0.2714	(35)
$HgZn_2$	−32 to +15	0.2806	(35)
$HgZn_2$	15 to 89	0.3276	(35)
	Hg-Pb		
49.2	−30 to +15	0.1447	(35)
49.2	23 to 99	0.1605	(27)
49.2	15 to 89	0.1772	(35)
32.6	−25 to +15	0.1401	(35)
32.6	15 to 89	0.1358	(35)
12.2	−34 to +15	0.1276	(35)
12.2	15 to 89	0.1293	(35)
	Hg-Sn		
10.0	0 to 97	0.2289	(17)
20.0	0 to 97	0.2243	(17)
30.0	0 to 97	0.2884	(17)

Hg-Sn.—(*Continued*)

Formula or Wt. % Hg	t or Δt, °C	c_p or c_m, joule/g	Lit.
40.0	0 to 97	0.2875	(17)
50.0	0 to 97	0.2879	(17)
60.0	0 to 97	0.2867	(17)
70.0	0 to 97	0.2821	(17)
80.0	0 to 97	0.2691	(17)
90.0	0 to 97	0.2528	(17)
Hg_2Sn	−23 to +15	0.1649	(35)
Hg_2Sn	15 to 89	0.3101	(35)
HgSn	−30 to +15	0.1709	(35)
HgSn	15 to 89	0.2980	(35)
HgSn	22 to 99	0.3053	(27)
$HgSn_2$	−24 to +15	0.1927	(35)
$HgSn_2$	15 to 89	0.2729	(35)
$HgSn_2$	21 to 99	0.2758	(27)
$HgSn_3$	−23 to +15	0.2009	(35)
$HgSn_3$	15 to 89	0.2421	(35)
$HgSn_4$	−30 to +15	0.2061	(35)
$HgSn_4$	15 to 89	0.2451	(35)
$HgSn_5$	−16 to +15	0.2109	(35)
$HgSn_5$	15 to 89	0.2319	(35)

NON-FERROUS ALLOYS

Two-Component

Ag-Al

Ag_3Al, Mol. wt. = 350.6; C_p, joule/mole

$t°$	−150	−100	−50	0	+50	(32)
C_p	79.84	87.47	93.49	97.74	100.4	
$t°$	200	300	400	500	600	(34)
C_p	106.1	109.2	111.6	114.5	116.9	

$t°$	18–100	18–300	18–600	100	(34)
C_p	100.2	104.6	108.6	101.8	
$t°$	−182 to +15	15–100	15–227	15–410	(36)
C_p	90.99	102.1	103.3	106.5	

Ag_2Al, Mol. wt = 242.72; C_p, joule/mole

$t°$	−150	−100	−50	0	+50	(32)
C_p	57.6	64.6	70.1	74.0	76.1	

$t°$	18–100	18–300	18–600	100	200	300	400	500	600	(34)
C_p	76.2	78.9	82.9	77.5	79.7	81.8	84.9	88.1	92.7	

$AgAl_{12}$ (36), Mol. wt. = 431.4

$t°$	−182 to +15	15–100	15–300	15–495
C_p	261.3	325.3	343.0	378.0

Ag-Au

c_p, joule/g (31)

Ag, 80%	$t°$	−136	−39	+12
Au, 20%	c_p	0.1921	0.2072	0.2147

Ag-Mg

AgMg, Mol. wt. = 132.2; C_p, joule/mole

$t°$	−150	−100	−50	0	+50	17–100	(32)
C_p	36.6	41.4	45.0	47.5	48.9	48.9	

$t°$	18–100	18–300	100	200	300	400	500	600	(34)
C_p	49.3	51.5	50.4	52.1	53.9	55.6	57.7	59.2	

Ag-Sb

Ag_3Sb, Mol. wt. = 445.41; C_p, joule/mole

$t°$	−150	−100	−50	0	+50	(32)
C_p	86.0	94.2	99.9	103.4	103.5	

$t°$	100	200	300	18–100	18–300	(34)
C_p	104.4	107.0	117.5	103.3	107.0	

Ag-Te

Ag_2Te [36], Mol. wt. = 343.26

$t°$	−182 to +15	15–100	15–180	15–390
C_p	74.1	96.6	98.6	95.3

Al-Bi

Al, 94 %; c_m(20–100°) = 0.4367 [33].

Al-Cu

Al_2Cu, Mol. wt. = 117.49

$t°$	−150	−100	−50	0	+50	[32]	18–100	18–300	18–600	[34]
C_p	48.8	58.7	66.1	71.1	73.7		73.6	61.1	79.2	

AlCu, Mol. wt. = 90.53

$t°$	−150	−100	−50	0	+50	[32]
C_p	31.7	38.1	43.0	46.4	48.4	

$t°$	100	200	300	400	18–200	18–400	[34]
C_p	49.6	51.7	53.5	56.6	49.6	51.5	

Al_2Cu_3, Mol. wt. = 244.63

$t°$	100	200	300	400	500	[34]
C_p	92.4	96.0	98.7	100.8	102.3	

$AlCu_2$, Mol. wt. = 154.1

$t°$	100	200	300	400	500	[34]
C_p	70.5	73.2	75.7	77.7	81.3	

$AlCu_3$, Mol. wt. = 217.67

$t°$	−150	−100	−50	0	+50	[32]	
C_p	68.0	79.8	88.7	94.5	97.5		joule/mole

$t°$	18–100	18–300	18–400	[34]	
C_p	97.3	101.1	104.8		joule/mole

Al, 11.3 %, soft bronze; c_m (20–100°) = 0.437 [16].
Al, 60 %; c_m(20–100°) = 0.702 [33] joule/g.

Al-Mg

Al, 92 %; c_p(room) = 1.15 joule/g [38].

Al-V

Al, 32.1 %; c_m(15–100°) = 0.655 joule/g [18].

Al-Zn

Al, 60 %; c_m(20–100°) = 0.565 joule/g [33].

As-Sb

c_p, joule/g [30]

$t°$	29.6 % As	16.75 % As	5.56 % As
−190 to −88	0.2176	0.2059	0.1938
−75 to 0	0.2264	0.2264	0.2097
0 to 25	0.2390	0.2331	0.2185

Au-Cu

Au, 80 %; c_p = 0.1636 at −136°, =0.1799 at −39°,
= 0.1829 at +12°, joule/g [31].

Au-Mg

Form.	Mol. wt.	$t°$	−150	−100	−50	0	+50	
AuMg	221.52	C_p	36.3	41.3	45.1	47.9	49.8	joule/mole [32]
$AuMg_2$	245.84	C_p	52.1	59.5	65.7	70.3	73.6	
$AuMg_3$	270.16	C_p	65.7	77.2	86.3	93.0	97.1	

Bi-Cd

c_m(17–100°) = 0.2347 − 0.00108 × % Bi, from 40 to 90 % Bi [14].

Bi-Pb

c_m(0–100°) = 0.1298 + 0.00013 × (% Bi), from 0 to 50 % [29].
c_m(0–100°) = 0.1471 − 0.00217 × (% Bi), from 50 to 96 %.

Bi-Sn

Wt. % Bi	99	97	94	90	85	
c_m(0–100°)	0.1266	0.1315	0.1340	0.1398	0.1433	joule/g [29]

Wt. % Bi	50	25	15	7	3	
c_m(0–100°)	0.1817	0.2088	0.2221	0.2236	0.2266	joule/g [29]

Bi, 56.9 %; c_m,(17–99°) = 0.1883, c_m(146–257°, liq.) = 0.1900 [25].

Bi, 44 %; c_m(44–56°) = 0.1759 [13].

Cd-Sn

Cd, 32.2 %; c_m(−77 to +20°) = 0.2317; (20–100°) = 0.2344 [35].

Co-Sb

CoSb, Mol. wt. = 180.74 [32]

$t°$	17–100	−150	−100	−50	0	+50	
C_p	51.2	38.1	42.7	46.5	49.3	51.1	joule/mole

Co-Sn

Co_2Sn, Mol. wt. = 236.64

$t°$	−150	−100	−50	0	+50	17–100	[32]
C_p	56.7	64.6	70.9	75.8	79.2	79.4	

$t°$	18–100	18–200	100	200	300	400	500	600	joule/
C_p	79.4	84.4	81.9	86.8	89.2	91.7	93.5	95.2	mole [34]

Cr-Sb

$CrSb_2$, Mol. wt. = 295.55; C_m(17–100°) = 83.2 joule/mole [32]
CrSb, Mol. wt. = 173.78 [32]

$t°$	−150	−100	−50	0	+50
C_p	35.5	41.5	46.5	50.3	53.1

Cu-Mg

Cu_2Mg, Mol. wt. = 151.46

$t°$	−150	−100	−50	0	+50	[32]
C_p	45.4	52.2	57.3	60.7	62.4	

$t°$	18–100	18–300	18–500	100	200	300	400	[34]
C_p	73.5	76.4	80.5	75.1	78.0	81.3	86.5	

$CuMg_2$, Mol. wt. = 112.21 [32]

$t°$	−150	−100	−50	0	+50	
C_p	49.7	57.7	63.9	68.4	71.2	joule/mole

Cu-Mn

Wt. % Cu	$t°$	−136	−39	+12	
90	c_p	0.323	0.376	0.396	joule/g [31]
68	c_p	0.346	0.400	0.414	

Cu-Ni

Wt. % Cu	$t°$	−136	−39	+12
95 [31]	c_p	0.3059	0.3575	0.3792
90 [31]	c_p	0.3072	0.3662	0.3800

Wt. % Cu	$t°$	0	18	100
40 [11]	c_p	0.4102	0.4089	0.4269
Constantan				

Cu-Sb

Cu_2Sb, Mol. wt. = 248.91

$t°$	−150	−100	−50	0	+50	[32]
C_p	60.6	67.3	72.3	75.6	77.1	

$t°$	100	200	300	18–100	18–300	[34]
C_p	79.2	81.7	84.0	77.7	80.5	

Cu_3Sb, Mol. wt. = 312.48

$t°$	−150	−100	−50	0	+50	17–100	[32]
C_p	81.7	90.8	97.6	102.0	104.1	102.5	

$t°$	18–200	18–400	100	200	300	400	[34]
C_p	105.0	107.0	106.6	109.5	112.5	116.4	

Cu-Si

Cu_3Si, Mol. wt. = 218.77; C_m(17–100°) = 97.4 joule/mole.

Cu-Sn

Cu, 80 %, bell bronze; c_m(15–98°) = 0.36 [28]; c_m(18–100°) = 0.2279 + 0.0015505 × % Cu, joule/g (from 10 to 90 %) [8].

Cu-Zn, Brasses

c_m(18–100°) = 0.3863 + 0.0000232 × % Zn, joule/g (from 10 to 90 %) (8).

Cu, 60 %; c_m(−186 to −79°) = 0.311 (1, 2); (−187 to +19°), = 0.414 (3) = 0.339 (2); (20–100°), = 0.384 (37).

Cu, 60 %; with 1.2 % Si + 0.44 % Pb; c_m(−79 to +18°) = 0.460 (2).

Ir-Pt

c_m(20–100°) = 0.1352 for 10 % Ir (26).

Mg-Ni

$MgNi_2$, Mol. wt. = 83.01

t°	−79 to +17	17–100	(32)
C_p	63.3	74.4	

t°	18–100	18–300	18–500	100	200	300	400	500	600	(34)
C_p	74.4	74.5	81.9	77.3	81.2	83.6	86.6	87.8	89.4	

Mg-Si

Mg_2Si, Mol. wt. = 76.70

t°	−150	−100	−50	0	+50	17–100	(32)	100	300	600	(34)
C_p	41.4	52.3	60.8	66.7	70.2	70.3		72.2	78.8	84.7	

Mg-Sb

Mg_3Sb_2, Mol. wt. = 316.5

t°	−150	−100	−50	0	+50	(32)
C_p	90.4	105.6	116.3	123.4	125.9	

Mg-Zn

$MgZn_2$, Mol. wt. = 145.08

t°	−150	−100	−50	0	+50	17–100	(32)
C_p	57.3	63.9	69.1	72.7	75.0	75.0	

t°	18–100	18–300	100	200	300	400	(34)
C_p	75.0	78.4	76.6	80.0	83.9	94.1	

Mn-Ni

% Mn (31) =	95			90			55		
t°	−136	−39	+12	−136	−39	+12	−136	−39	+12
c_p	0.387	0.435	0.445	0.386	0.435	0.459	0.386	0.448	0.464

Ni-Si

Ni_2Si, Mol. wt. = 145.44

t°	−150	−100	−50	0	+50	(32)
C_p	42.9	53.6	61.9	67.6	70.7	

t°	100	200	300	400	500	600	(34)
C_p	72.4	76.1	78.5	80.4	82.5	84.4	

NiSi, Mol. wt. = 86.75

t°	−150	−100	−50	0	+50	17–100	(32)
C_p	25.8	33.5	39.5	43.7	46.3	46.3	

t°	300	400	500	600	(34)
C_p	52.1	54.0	55.8	57.3	

Ni-Te

NiTe (36), Mol. wt. = 186.19

t°	−182 to +15	15–100	15–180	15–385
C_p	44.8	65.7	53.7	54.8

Pb-Sb

c_m(20–100°) = 0.2078 − 0.000790 × % Pb (from 21 to 90 %) (6); = 0.1301 + 0.000815 × % Sb (from 5 to 96 %) (15) joule/g.

Pb-Sn

Pb, Wt. = 63.7 %

t°	−178 to −79	−79 to +18	12–99
c_m	0.1507 (2)	0.1628 (2)	0.1705 (28)

Pb-Tl

Pb, 35 %; c_m(0–25°) = 0.1281 (31).

S-Se

% S (3)	4	9	28.8	90.35	90.35
c_m(0–41°)	0.3742	0.3906	0.4700	0.6831*	0.7158†

* S rhombic. † S monoclinic.

S-Te

c_m(0–41°) = 0.3202 (for 80 % S); = 0.2913 for 60 % S (23).

Sb-Zn

SbZn (32), Mol. wt. = 187.15

t°	−150	−100	−50	0	+50
C_p	40.74	45.91	49.59	51.78	52.49

Sn-Te

SnTe (36), Mol. wt. = 373.7

t°	−182 to +15	15–100	15–180	15–327
C_m	73.7	77.1	76.5	77.6

Sn-Zn

c_m(16–100°) = 0.2294 + 0.001636 × % Zn (from 10 to 90 %) (8).

THREE- AND FOUR-COMPONENT ALLOYS

Heussler alloy, Al, 9; Mn, 17; Cu, 74; c_m (0–46°) = 0.4432; = 0.4482 after tempering; for values up to 320°, *v.* (39)

d'Arcet's alloys

% Bi	% Pb	% Sn	t°	c_m	Lit.
49.2	27.6	21.2	−68 to +20	0.1456	(35)
49.2	27.6	21.2	20 to 86	0.2444	(35)
49	32.5	18.5	12 to 50	0.2051	(25)
49	32.5	18.5	14 to 80	0.2511	(25)
49	32.5	18.5	107 to 136	0.1967*	(25)
49	32.5	18.5	136 to 300	0.1506*	(25)
49.2	32.4	18.4	5 to 65	0.1557	(19)
49.2	32.4	18.4	120 to 150	0.1670*	(19)

Rose metal

% Bi	% Pb	% Sn	t°	c_m	Lit.
48.9	27.5	23.6	−77 to +20	0.1490	(35)
48.9	27.5	23.6	20 to 89	0.2310	(35)
48.9	27.5	23.6	19 to 74	0.2545	(27)
48.7	24	27.6	15 to 65	0.1765	(19)
48.4	24.1	27.5	199 to 338	0.1765*	(25)
32	31.8	36.25	18 to 52	0.1770	(27)
32	31.8	36.25	11 to 98	0.1873	(24)
32	31.8	36.25	143 to 330	0.1925*	(24)

* Liquid.

Lipowitz alloy

Bi, 50.7; Cd, 10.1; Pb, 25.0; Sn, 12.2; c_m(5–50°) = 0.1444; (100–150°, liq.) = 0.1783 (19).

Wood's metal

Bi, 52.43; Cd, 6.99; Pb, 25.9; Sn, 14.7; c_m(5–50°) = 0.1473; (100–150°, liq.) = 0.1783 (19).

Manganin

Cu, 84; Ni, 4; Mn, 12; c_p(0°) = 0.406; (18°) = 0.4073; (100°) = 0.4202 joule/g (11).

Phosphor bronze

Cu, 88; Sn, 12; P, 0.94; c_m(−188 to +18°) = 0.3348 (4); (20–100°) = 0.3657 (37).

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(For a key to the periodicals see end of volume)

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HEAT CAPACITY OF SOLUTIONS

B. L. VANZETTI

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The values recorded are the true heat capacity at constant pressure, c, (at $t°$) or the mean heat capacity, c_m (over Δt). The unit in all cases is absolute joules per g of solution per °C. 1 abs. joule = 0.23895 cal_{15} = 0.23918 cal_{20} = 0.0009482 BTU_{60}. (*See further*, Vol. I, p. 24.)

Where equations are given, p = Wt. % of solute. In general, values computed from these equations may be relied upon to *ca.* ±0.01 joule.

TWO-COMPONENT SYSTEMS

Aqueous Solutions

𝔅-TABLE, STANDARD ARRANGEMENT (*v.* Vol. III, p. viii)

H_2O_2, 20–50°C (54)

%	c_m
30.59	3.98
34.25	3.68
60.48	3.27
71.54	3.19
74.54	(3.28)

HF, Room temp. (41, 48)

%	c
5	3.96
10	3.80
15	3.65
20	3.49
25	3.33
30	3.17
35	3.02

HCl, *v.* p. 115

$HClO_3$, 18°C (24)

4	4.00
5	3.96
10	3.74
15	3.52
20	3.26
25	3.00

$HClO_4$, 13°C (3, 49)

2.5	4.06
5	3.96
10	3.76
15	3.57
20	3.37
45	(2.24)
47.5	2.12

HBr, 13–96°C, with 25%, c_m = 2.99 (58); 16–20°C, with 4.3%, c_m = 3.948 (50).

HI, 16–20°C, with 6.7%, c_m = 3.855 (50).

HIO_3, 18°C (24)

%	c
8	3.85
10	3.77
15	3.60
20	3.42
25	3.24
30	(3.05)
35	2.84
40	2.69

H_2SO_4, *v.* p. 115

NH_3, *v.* p. 115

HNO_3, 20°C (39, 45, 49, 57)

%	c
1	4.13
2.5	4.04
5	3.92
10	3.72
15	3.55
20	3.38
25	3.22
30	3.08
40	2.80
45	2.77
50	2.74
60	2.65
70	2.55
80	2.43

HNO_3.—(*Cont'd*)

%	c
90	2.23
98	1.99

NH_4NO_3, 32°C (12); *cf.* (39, 57, 63), $c = 4.1787 - 32.051 \times 10^{-2}p - 128.944 \times 10^{-6}p^2 - 270.89 \times 10^{-9}p^3$, range, 5–70%.

NH_4Cl, 18°C (57); *cf.* (16, 39, 63), $c = 4.189 - 43.63 \times 10^{-3}p + 429.9 \times 10^{-6}p^2$, range, 5–28%.

$NH_2OH.HCl$, 18.7°C (15)

%	c
7.2	3.98
1.9	4.085

NH_4Br, 18°C (13, 50)

2.5	4.055
5	3.95
10	3.73
15	3.50
20	3.27
25	3.04
28	2.90

NH_4I, 18°C, c = 3.9 with 3.5%; = 4.03 with 4% (57).

$(NH_4)_2SO_4$, 18°C (39, 57), $c = 4.1605 - 42.58 \times 10^{-2}p + 296 \times 10^{-6}p^2$, range, 3.5–33%.

$(NH_2OH)_2.H_2SO_4$, 18.6°C (15)

%	c
15.4	3.97
4.36	4.08s

H_3PO_4, 0–15°C, with 19.04%, c_m = 3.79 (1).

For C-Compounds, *v.* p. 124

ZrO_2,* 3–80°C (23)

% H_2O	c_m
0†	0.55
0.0075	0.60
8.25	0.70
17.3	0.92
24.3	1.243
33.0	1.675
38.2	1.81
56.9	2.565
71.7	3.37

* Colloidal. † Ignited.

$Pb(NO_3)_2$, 18°C (5, 24, 39, 37), $c = 4.156 - 40.9 \times 10^{-3}p + 66.1 \times 10^{-6}p^2$, range 3–48%.

$Pb(C_2H_3O_2)_2$, Acetate, 18–51°C (39, 56)

%	c_m
10	3.85
15	3.696
20	3.53
25	3.37
30	3.2
35	3.06
40	2.91

$ThCl_4$, 18°C (24)

%	c
5	3.93
10	3.68
15	3.43
20	3.19
25	2.93
27.2	2.87

$InBr_3$, 18°C (24)

%	c
5	3.97
10	3.76
15	3.54
20	3.32
25	3.10
30	2.87
32	2.78

TlF, 18°C (24)

5	3.94
10	3.73
15	3.50
20	3.28
25	3.07
30	2.87

$ZnCl_2$, 0–50°C (7, 39), $c_m = 4.185 - 37.61 \times 10^{-3}p + 29.04 \times 10^{-6}p^2$, range, 0–65%.

$ZnSO_4$, 19°C (12), $c = 4.185 - 51.626 \times 10^{-3}p + 323.6 \times 10^{-6}p^2$, range, 2.5–35%.

$Zn(NO_3)_2$, 20–50°C (39), $c_m = 4.185 - 47.09 \times 10^{-3}p + 266.6 \times 10^{-6}p^2$, range, 5–50%.

$Zn(C_2H_3O_2)_2$, Acetate 19–51°C (39)

%	c_m
5	4.07
10	3.976
15	3.87
20	3.75
25	3.64

CdI_2, 19°C (12), $c = 4.1816 - 35.62 \times 10^{-3}p - 177.5 \times 10^{-6}p^2 + 2344 \times 10^{-9}p^3$, range, 8–45%.

$CdSO_4$, 19°C (10, 22), $c = 4.167 - 47.49 \times 10^{-3}p + 164.3 \times 10^{-6}p^2$, range, 2–45%.

$HgCl_2$, 0–98°C (7)

%	c_m
1	4.14
2	4.06
3	3.97

18°C (24)

%	c
2	4.12
4	4.05
6	3.99

$CuCl_2$, 19–51°C (39)

%	c_m
3.5	4.00
5	3.94
10	3.73
15	3.54
20	3.37
25	3.20
30	3.03
35	2.87
40	2.70
42.5	2.62

$CuSO_4$, 18°C (39, 42, 57, 60)

%	c
2	4.09
5	3.95
10	3.73
15	3.50
17	(3.41)

$Cu(NO_3)_2$, 18–50°C (39)

%	c_m
5	3.96
10	3.74
15	3.54
17.5	3.44

$AgNO_3$, 25–52°C (39)

8.5	3.83
10	3.77
15	3.59

$AgNO_3$.—(*Cont'd*)

%	c_m
20	3.41
25	3.22
27.5	3.13

$MnCl_2$, 20–50°C (7, 39)

3.5	3.98
5	3.91
10	3.70
15	3.52
20	3.34
30	3.03
40	2.76
50	2.51

$MnSO_4$, 20–50°C (39)

4	3.99
5	3.94
10	3.71
15	3.52

$Mn(NO_3)_2$, 20–50°C (39)

5	3.94
10	3.73
15	3.52

$Mn(C_2H_3O_2)_2$, Acetate, 19–52°C (39)

5	4.03
10	3.896
15	3.766

$FeCl_3$, 0–98°C (7), $c_m = 4.274 - 54.72 \times 10^{-3}p + 461.6 \times 10^{-6}p^2$, range, 20–44%.

$FeSO_4$, 25–45°C (1); *cf.* (57)

%	c_m
1	4.093
2	4.00
5	3.829
10	3.633
15	3.474
20	3.335
25	3.20
30	3.066
35	2.95

$CoCl_2$, 15–49°C (56)

8.9	3.62
16.4	3.21
18–90°C	
8.9	3.75
16.4	3.294

$NiCl_2$, 24–55°C (38)

5	3.87
10	3.61
15	3.38
20	3.17

$NiSO_4$, 26–56°C (38)

5	3.94
10	3.72
15	3.49

$Ni(NO_3)_2$, 24–55°C (38)

%	c_m
5	3.93
10	3.71
15	3.52
20	3.33
25	3.15
28.9	3.00

$Ni(C_2H_3O_2)_2$, Acetate, 26–56°C (39)

5	4.03
10	3.907
15	3.78

CrO_3, 15°C (9, 39), $c = 4.185 - 0.4612p + 0.0002p^2$, range, 0–62%.

$(NH_4)_2CrO_4$, 21–53°C (39), $c_m = 4.174 - 35.12 \times 10^{-3}p + 67.1 \times 10^{-6}p^2$, range, 4–25%.

$AlCl_3$, 18°C (24), $c = 4.165 - 69.51 \times 10^{-3}p + 321.9 \times 10^{-6}p^2$, range, 2–15%.

$Al_2(SO_4)_3$, 21–53°C (39), $c_m = 4.187 - 38.13 \times 10^{-3}p + 241.3 \times 10^{-6}p^2$, range 3–20%.

$Al(NO_3)_3$, 18°C (24), $c = 4.181 - 52.71 \times 10^{-3}p + 274 \times 10^{-6}p^2$, range, 3.5–25%.

$AlNH_4(SO_4)_2$, 20°C (5), $c = 4.156 - 38.21 \times 10^{-3}p + 118 \times 10^{-6}p^2$, range, 5–37.5%.

$La(NO_3)_3$, 18°C (24)

%	c
5	3.94
10	3.71
15	3.49
20	3.26
25	3.04
30	2.81

$Sa(NO_3)_3$, 18°C (24)

5	3.96
10	3.76
15	3.55
20	3.36
25	3.15

$DeCl_2$, 18°C (24)

2	4.06
5	3.88
10	3.53
14	3.33

$BeSO_4$, 21–52°C (39)

%	c_m
2.5	4.07
5	3.98
10	3.79
15	3.61
20	3.44

$Be(NO_3)_2$, 18°C (24)

%	c
3	4.03
5	3.94
10	3.71
15	3.48
20	3.26

$MgCl_2$, 20–52°C (39); *cf.* (20) (*v.* Fig. 1 and Vol. II, p. 328), $c_m = 4.185 - 65.7 \times 10^{-3}p + 565 \times 10^{-6}p^2$, range, 5–25%.

$MgBr_2$, 18°C (24)

%	c
2.5	3.95
5	3.74
10	3.33
15	2.96
17.5	2.78

$MgSO_4$, 18°C (5, 36, 42, 57)

3	3.99
5	3.90
10	3.67
15	3.46
20	3.28
Supersaturated solutions	
25	3.11
30	2.94
35	2.75
37.5	2.65

$Mg(NO_3)_2$ 21–52°C (39), $c_m = 4.173 - 46.29 \times 10^{-3}p + 237.8 \times 10^{-6}p^2$, range, 5–35%.

$Mg(C_2H_3O_2)_2$, Acetate, 21–52°C (39)

%	c_m
5	4.03
10	3.89
14	3.78

$CaCl_2$, 18°C, $c = 15.401 - 17.016d + 5.608d^2$ between $d_4^{18} = 1.09$ and 1.41 (59); *cf.* (14), $c_m = 17.297 - 19.92d + 6.696d^2 - 0.00263(20^\circ - t)$, for $d_4^{20} = 1.175$ to 1.250 and for any

$CaCl_2$.—(*Cont'd*) value of t between −25 and 20°C (11). *See further* Fig. 2 *and also* Vol. II, p. 328.

CaS_2O_3, Room temp. (4), $c = 4.147 - 44.9 \times 10^{-3}p$, range, 3–25%.

$Ca(NO_3)_2$, 21–51°C (39), $c_m = 4.163 - 42.61 \times 10^{-3}p + 213.8 \times 10^{-6}p^2$, range, 5–47.5%.

$Ca(C_2H_3O_2)_2$, Acctate, 20–52°C (39)

%	c_m
5	4.02
10	3.875
15	3.74

$SrCl_2$, 19–51°C (39)

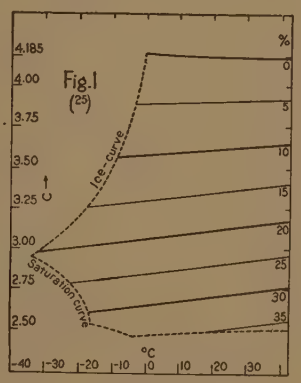
%	c_m
4	3.95
5	3.90
10	3.65
15	3.42

$Sr(NO_3)_2$, 19–51°C (39)

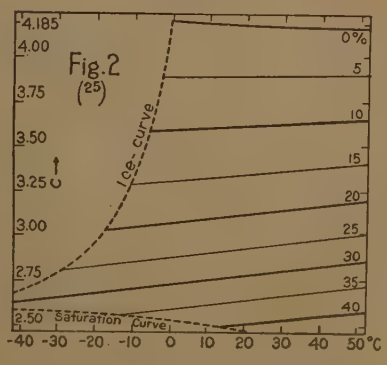
5	3.96
10	3.75
15	3.56
20	3.38

$Sr(C_2H_3O_2)_2$ Acetate, 20–52°C (39)

5	3.996
10	3.83
15	3.67
18.6	3.56



$MgCl_2$



$CaCl_2$

$BaCl_2$, 18°C (7, 16, 39, 57), $c = 4.223 - 58.38 \times 10^{-3}p + 318 \times 10^{-6}p^2$, range, 4–25%.

$Ba(NO_3)_2$, 18°C (39, 57), $c = 3.90$ with 6.8%.

$Ba(C_2H_3O_2)_2$, Acetate, 19–52°C (39)

%	c_m
6	3.955
10	3.81
15	3.65
20	3.49

LiOH, 20°C (49)

%	c
0.5	4.17
1.0	4.12
2.5	4.06
5.0	3.99

LiCl, 18°C (24, 32, 45, 49)

0.5	4.15
2.5	4.04
5.0	3.92
10	3.68
15	(3.48)
20	(3.30)
25	(3.13)
30	2.98
35	2.83
40	2.69

$LiClO_3$, 18°C (24)

5.0	3.98
10	3.78
15	3.58
20	3.36
25	3.14

LiBr, 18°C (24)

5.0	3.94
10	3.71
15	3.47
20	3.22
25	2.97

LiI, 18°C (24)

5.0	3.96
10	3.73
15	3.49
20	3.26
25	3.02
30	2.77

$LiIO_3$, 18°C (24)

8.0	3.85
10	3.78
15	3.59
20	3.41
25	3.22
30	3.04
35	2.86

$LiNO_3$, 20°C (49)

1.0	4.15
5.0	4.01
10	3.82
13	3.70

NaOH, *v.* p. 115

NaCl, *v.* p. 115

NaBr, 18°C (16, 24, 39), $c = 4.155 - 45.34 \times 10^{-3}p + 135.9 \times 10^{-6}p^2$, range, 5–35%.

NaI, 18°C (16, 24, 39, 57), $c = 4.180 - 47.55 \times 10^{-3}p + 126.3 \times 10^{-6}p^2$, range, 4–40%.

Na_2SO_4, 18°C [39, 56, 57], $c = 4.167 - 47.36 \times 10^{-3}p + 675 \times 10^{-6}p^2$, range, 3–24 %.

$NaHSO_4$, 21°C [39]

%	c
3	4.08
5	4.01
10	3.88
15	3.75
20	3.65

$NaNO_3$, 20°C [39, 47, 49, 57], $c = 4.175 - 37.42 \times 10^{-3}p + 216.6 \times 10^{-6}p^2$, range, 1–39 %.

$NaPO_3$, 24–55°C [39]

%	c_m
3	4.07
5	4.00
10	3.83
15	3.67
18.5	3.56

NaH_2PO_4, 24–55°C [39]

3	4.07
5	4.00
10	3.85
15	3.70
20	3.56

Na_2HPO_4, 24–55°C [39]

3.8	4.02
7.3	3.91

$Na_4P_2O_7$, 24–55°C [39]

3.6	4.04
6.8	3.92

NaH_2AsO_4, 26–57°C [39]

5	3.99
10	3.82
15	3.66
18.5	3.50
25	3.35

Na_2HAsO_4, 25–56°C [39]

5	3.97
10	3.79
15	3.64
17.5	3.57

Na_2CO_3, 20°C [39, 57]

%	c
2.5	4.05
5	3.94
10	3.77
15	3.66
20	3.59

Na_2CrO_4, 21–52°C [39], $c_m = 4.159 - 43.13 \times 10^{-3}p + 363.5 \times 10^{-6}p^2$, range, 5–25 %.

$NaHCO_2$, Formate, 16°C [18]

%	c
3.6	4.04
7.8	3.90
13.1	3.73

$NaC_2H_3O_2$, Acetate, 18–20°C [5, 39, 57]

%	c_m
2	4.12
5	4.02
10	3.88
15	3.76
20	3.65
25	3.54
30	3.44

KOH, *v.* p. 115

KF, 18°C [24], $c = 4.176 - 54.7 \times 10^{-3}p + 380.9 \times 10^{-6}p^2$, range, 4–20 %.

KCl, *v.* p. 115

$KClO_3$, 20°C [5], $c = 4.170 - 56.33 \times 10^{-3}p + 396 \times 10^{-6}p^2$, range, 5–25 %.

KBr, 18°C [16, 39, 57], $c = 4.177 - 47.81 \times 10^{-3}p$, range, 3–30 %.

KI, 18°C [16, 39, 55, 57]

%	c
4	4.00
5	3.95
10	3.71
20	3.23
30	2.75
40	(2.32)
50	(1.9)
60	(1.5)

K_2SO_4, *ca.* 18°C [39, 55, 57]

4	4.02
5	3.92
6	3.85
8	3.77

KNO_3, 20°C [39, 47, 49, 57, 63], $c = 4.172 - 44.3 \times 10^{-3}p + 421.2 \times 10^{-6}p^2$, range, 2.5–20 %.

K_2CO_3, 21–52°C [39], $c = 4.179 - 49.23 \times 10^{-3}p + 331.2 \times 10^{-6}p^2$, range, 5–45 %.

$K_2C_2O_4$, 21–52°C [39]

%	c_m
5	3.95
10	3.73
15	3.53

$KC_2H_3O_2$, Acetate, 20–51°C [39]

5	4.005
10	3.83
15	3.68
20	3.54
25	3.40
30	3.26
35	3.13
40	3.0
45	2.86
50	2.73

K_2CrO_4, 18°C [16, 39], $c = 4.172 - 50.52 \times 10^{-3}p + 234.7 \times 10^{-6}p^2$, range, 5–30 %.

$KAl(SO_4)_2$, 20°C [5], $c = 4.205 - 41.42 \times 10^{-3}p + 254.4 \times 10^{-6}p^2$, range, 6–40 %.

$KNa(NO_3)_2$ [47], $c = 4.01$ with 4.7 %; $= 3.59$ with 16.7 %.

RbCl [49]

RbBr, 18°C [24]

%	c
7.5	3.82
10	3.70
15	3.45
20	3.19
25	2.93

$RbNO_3$ [49]

CsCl, 20°C [49]

2	4.08
5	3.94
10	3.70
15	3.47

CsBr, 18°C [24]

8	3.71
10	3.61
15	3.31
20	3.00
25	2.68
30	2.40
35	2.15
40	1.94

$CsNO_3$, 20°C [49]

2.5	4.07
5	3.96
10	3.74
15	3.54

℄-Table, ℄-Arrangement (*v.* Vol. III, p. viii)

M_A/M_B = Moles H_2O per Mole Solute

CH_2O_2, Formic acid, 16–50°C [18, 33]

M_A/M_B	c_m
200	4.15
100	4.12
50	4.06
40	4.02
30	3.97
20	3.90
15	3.84
10	3.73
8	3.66
6	3.54
5	3.46
4	3.38
3	3.28
2	3.02
1.5	2.94
1.0	2.91
0.5	2.80
0	2.24

CH_4N_2O, Urea, 16–20°C [18, 31, 34, 36]

%	c_m
1	4.16
2.5	4.11
5	4.05
7.5	3.98
10	3.90
12	3.85

CH_4O, Methyl alcohol, *v.* p. 116

CH_5NO_2, Ammonium formate, 8.5°C [18]

%	c
1.7	4.12
3.4	4.06
6.5	3.95

$C_2HCl_3O_2$, Trichloroacetic acid, 14°C [18]

200	4.09
100	4.00
50	3.84

$C_2H_2Cl_2O_2$, Dichloroacetic acid, 18°C [18]

M_A/M_B	c
200	4.12
100	4.06

$C_2H_3ClO_2$, Chloroacetic acid, 18°C [18]

200	4.16
100	4.10
50	4.01
25	3.85

$C_2H_2O_4$, Oxalic acid, 20–52°C [39]

M_A/M_B	c_m
200	4.11
100	4.03
50	3.94

$C_2H_4Cl_3NO_2$, Ammonium trichloroacetate, 12°C [18]

%	c
4.9	4.09
9.3	4.04

$C_2H_4Cl_3NO_3$, Hydroxylamine trichloroacetate, 19°C [15]

5.18	4.08
9.85	3.99

$C_2H_4O_2$, Acetic acid, *v.* p. 115

C_2H_5NO, Acetamide, *ca.* 20°C [34]

1.6	4.156
3.2	4.13

C_2H_6O, Ethyl alcohol, *v.* p. 116

$C_2H_6O_2$, Glycol, 20°C [53]

%	c
10	4.15
20	3.96
30	3.75
40	3.58
50	3.38
60	3.185
70	3.01
80	2.82
90	2.63
100	2.356

$C_2H_7NO_2$, Ammonium acetate, 17.5°C [18]

2.1	4.13
4.1	4.08
7.9	3.98
14.6	3.81

C_3H_6O, Acetone, *ca.* 17°C [51]

0	4.181
10	4.15
20	4.08
30	3.98
40	3.87
50	3.75
60	3.56
70	3.33
80	3.01
90	2.66
100	2.196

$C_3H_6O_2$, Propionic acid, 22–50°C [18, 33]

M_A/M_B	c_m
100	4.16
50	4.12
40	4.11
30	4.09
20	4.03
15	4.01
10	3.88
8	3.76
6	3.63
5	3.55
4	3.43
3	3.26
2	3.03
1.5	2.91
1.0	2.82
0.5	2.48
0	2.19

$C_3H_6O_3$, Lactic acid, *ca.* 16°C [18]

M_A/M_B	c
200	4.14
100	4.11
50	4.06
25	3.96

C_3H_8O, Propyl alcohol, *v.* p. 116

$C_3H_8O_3$, Glycerol, *ca.* 20°C; *cf.* p. 116 [29, 34, 35, 36]

%	c
1	4.166
5	4.097
10	4.01

$C_4H_6O_6$, Tartaric acid, 18°C [57]

M_A/M_B	c
200	4.08
100	3.98
50	3.81
25	3.58
10	3.12

$C_4H_8O_2$, *n*-Butyric acid, 23–50°C [33]

M_A/M_B	c_m
50	4.17
40	4.06
30	4.00
20	3.92
15	3.81
10	3.64
8	3.54
6	3.41
5	3.32
4	3.21
3	3.06
2	2.86
1.5	2.79

$C_4H_8O_2$.—(*Cont'd*)

M_A/M_B	c_m
1.0	2.65
0.5	2.42
0	2.11

$C_4H_{10}O$, Isobutyl alcohol, 26–29°C, c_m = 4.55 with 7.6%; 25–28°C, c_m = 4.47 with 5.5% (44).

$C_4H_{12}ClN$, Tetramethylammonium chloride, 19°C, c = 4.07 with 2.94 % (15).

C_6H_6O, Phenol, 18–98°C (29); c_m = 4.152 with 2.54%; for data at 70–74°C, *v.* (16.5).

$C_6H_6O_2$, Hydroquinol, *ca.* 20°C (35)

%	c
1.5	4.158
2.0	4.15

$C_6H_6O_2$, Pyrocatechol, *ca.* 20°C (35)

1.5	4.165
2.0	4.16

$C_6H_6O_2$, Resorcinol, *ca.* 20°C (35)

1.5	4.158
2.0	4.15

C_6H_7N, Aniline, *v.* p. 115

$C_6H_8O_7$, Citric acid, 18°C (55)

M_A/M_B	c
200	4.03
100	3.90
50	3.72
25	3.45
15	3.19
10	2.98

$C_6H_{12}Cl_3NO_2$, Tetramethylammonium trichloroacetate, 19°C, c = 4.056 with 6.17% (15).

$C_6H_{12}O_6$, Dextrose *ca.* 20°C (34, 37, 55)

%	c
5	4.04
10	3.93
15	3.81
20	3.70
25	3.60
30	3.49
35	3.37
40	3.27
45	3.18
50	3.10
55	3.03

$C_6H_{12}O_6$, Levulose *ca.* 20°C (35, 36)

4.8	4.09
3.2	4.12
2.4	4.135

$C_6H_{14}O_6$, Dulcitol, *ca.* 20°C (35), c = 4.136 with 2.5% =4.147, with 2%.

$C_6H_{14}O_6$, Mannitol, *ca.* 20°C (35)

%	c
1	4.17
5	4.104
10	4.03

$C_8H_{24}N_2O_4S$, Tetramethylammonium sulfate, 18°C, c = 4.08 with 6.35% (15).

$C_{12}H_{22}O_{11}$, Lactose, *ca.* 20°C, c = 3.976 with 8.7%; =4.04 with 5.96% (35).

$C_{12}H_{22}O_{11}$, Maltose, *ca.* 20°C, c = 4.04 with 5.96%; = 4.074 with 4.54% (35).

$C_{12}H_{22}O_{11}$, Sucrose, *ca.* 20°C (29, 34, 36, 55); *cf.* (23)

%	c
5	4.04
10	3.89
15	3.77
20	3.64
30	3.39
40	3.14
50	2.94
60	2.83

$C_{14}H_{10}O_9$, Digallic acid, *ca.* 18°C, c = 4.10 with 4.28% (29).

Non-Aqueous Solutions

1. One Component an Inorganic Compound

H_2SO_4

B = HNO_3

20°C (45)

% B	c
0	1.402
5	1.423
10	1.440
20	1.490
25	1.515
30	1.548
40	1.5905
50	1.632
60	1.682
70	1.747
75	1.775
80	1.816
90	1.902
95	1.933
100	1.988

CS_2

ca. 20°C (38)

B = Br

% B	c
51	0.730

B = I

14.3	0.916
7.72	0.954

B = S

29.6	0.958
17.4	0.971
9.53	0.971
4.05	0.984

B = P

62	0.916
45	0.929
29	0.942
16.9	0.958
9.27	0.960

C_2H_6O

Ethyl alcohol, 99.3 %

d_4^{15} = 0.797; c_m = 2.858; 0–98°C (7)

B = $FeCl_3$

% B	c
5	2.72
7.5	2.67
10	2.624
15	2.54
20	2.45
25	2.35
30	2.26
32.1	2.226

B = $HgCl_2$

3	2.755
5	2.715
7.5	2.66
10	2.605

B = $HgCl_2$.—(*Cont'd*)

% B	c
15	2.51
18	2.45

B = $MnCl_2$

5	2.76
7.5	2.73
10	2.70
15	2.65
20	2.60
25	2.55

B = $ZnCl_2$

% B	c
8.5	2.584
10	2.554
15	2.44
20	2.325
25	2.19
30	2.06
35	1.94
40	1.855
45	1.75

C_5H_5N

Pyridine, 22°C (40)

B = $AgNO_3$

% B	c
1.06	1.600

B = AgCNS

1.03	1.593

B = $HgCl_2$

1.68	1.637

B = HgI_2

2.79	1.583

2. Both Components Organic Compounds C-Table.—

CCl_4

B = $CHCl_3$ (62)

M_B	M_A		20°C	30°C	40°C	50°C
1.00	0.00	c	0.9675	0.981	0.997	1.017
0.75	0.25	c	0.920	0.932	0.947	0.9655
0.50	0.50	c	0.886	0.8955	0.908	0.9235
0.25	0.75	c	0.8535	0.860	0.868	0.8795
0.00	1.00	c	0.833	0.8494	0.8535	0.860

B = C_6H_6 (62)

M_B	M_A		20°C	30°C	40°C	50°C	60°C
1.00	0.00	c	1.7075	1.737	1.763	1.8165	1.904
0.75	0.25	c	1.3875	1.400	1.421	1.456	1.551
0.50	0.50	c	1.138	1.1585	1.179	1.203	1.239
0.25	0.75	c	0.962	0.971	0.9835	1.004	1.038
0.00	1.00	c	0.833	0.8495	0.8535	0.860	0.889

% A (52)	20°C	35°C	50°C	% A (52)	20°C	35°C	50°C
0	1.7655	1.986	2.2055	60	1.004	1.197	1.398
10	1.630	1.851	2.065	70	0.927	1.102	1.270
20	1.493	1.716	1.925	80	0.858	1.010	1.147
30	1.358	1.580	1.786	90	0.816	0.930	1.034
40	1.222	1.429	1.654	100	0.807	0.878	0.939
50	1.100	1.305	1.527				

B = C_6H_7N, Aniline, 25°C (21)

% B	0	10	20	30	40	50
c	0.854	0.99	1.12	1.245	1.365	1.48

% B	60	70	80	90	100
c	1.60	1.72	1.82	1.93	2.026

CS_2

B = $CHCl_3$ (52)

% A	−30°C	−10°C	+20°C	% A	−30°C	−10°C	+20°C
0	0.9590	0.9698	0.9786	60	0.887	0.918	0.9685
10	0.942	0.956	0.973	70	0.886	0.921	0.971
20	0.926	0.941	0.971	80	0.898	0.927	0.977
30	0.911	0.935	0.9685	90	0.918	0.950	0.988
40	0.900	0.928	0.968	100	0.9728	0.9850	1.0050
50	0.891	0.922	0.967				

B = CH_4O, Methyl alcohol, *v.* p. 116

CS_2.—(*Continued*)

B = $C_4H_{10}O$, Ethyl ether [52]

% A	−30°C	−10°C	+20°C	% A	−30°C	−10°C	+20°C
0	2.0675	2.1412	2.2538	60	1.348	1.410	1.491
10	1.938	2.014	2.126	70	1.247	1.295	1.369
20	1.810	1.887	1.998	80	1.143	1.180	1.245
30	1.691	1.768	1.850	90	1.055	1.080	1.122
40	1.576	1.650	1.741	100	0.9728	0.9848	1.0056
50	1.455	1.530	1.613				

B = $C_{10}H_8$, Naphthalene, at *ca.* 18°C, c = 1.084 with 14.2% B [17]

$CHCl_3$

B = C_3H_6O, Acetone [62]

M_A	M_B		20°C	30°C	40°C
1.00	0.00	c	0.9677	0.9807	0.9969
0.75	0.25	c	1.172	1.183	1.197
0.50	0.50	c	1.356	1.377	1.404
0.25	0.75	c	1.6856	1.701	1.745
0.00	1.00	c	2.166	2.232	2.369

% B [52]	−40°C	−10°C	+20°C	35°C
0	0.9542	0.9698	0.9786	0.9850
10	1.333	1.270	1.191	1.144
20	1.651	1.506	1.392	1.314
30	1.814	1.674	1.572	1.480
40	1.876	1.781	1.727	1.625
50	1.87	1.848	1.833	1.743
60	1.82	1.896	1.925	1.856
70	1.80	1.942	2.009	1.965
80	1.82	1.992	2.084	2.067
90	1.88	2.042	2.147	2.155
100	1.9878	2.0897	2.1912	2.2265

B = $C_4H_{10}O$, Ethyl ether [52]

%A	−50°C	−30°C	−10°C	0°C	+20°C
0	1.955	2.067	2.1413	2.1796	2.2538
10	2.138	2.239	2.178	2.18	2.176
20	2.296	2.334	2.206	2.17	2.094
30	2.411	2.379	2.214	2.150	2.010
40	2.475	2.374	2.195	2.099	1.919
50	2.492	2.320	2.138	2.034	1.822
60	2.415	2.221	2.032	1.925	1.705
70	2.231	2.055	1.873	1.766	1.551
80	1.942	1.787	1.628	1.550	1.373
90	1.490	1.404	1.320	1.281	1.178
100	0.9475	0.961	0.9697	0.973	0.9785

B = C_6H_6, Benzene [52]

% A	6°C	20°C	55°C	% A	6°C	20°C	55°C
0	1.559	1.765	1.2796	60	1.275	1.375	1.554
10	1.527	1.704	2.158	70	1.202	1.286	1.420
20	1.488	1.642	2.037	80	1.121	1.186	1.278
30	1.442	1.578	1.915	90	1.042	1.084	1.136
40	1.392	1.514	1.793	100	0.974	0.979	0.994
50	1.336	1.447	1.672				

B = $C_{10}H_8$, Naphthalene, at 18°C, c = 1.033 with 9.6% B [17]

CH_2O_2

Formic acid

B = $C_2H_4O_2$, Acetic acid [30]

M_A	M_B	Range, °C	c_m
0.5	0.5	65–18	2.101

CH_4N_2O

Urea

B = C_2H_6O, Ethyl alcohol, *ca.* 20°C [34], c = 2.504 with 2.9%A; =2.507 with 1.7% A

CH_4O

Methyl alcohol

B = C_2H_6O, Ethyl alcohol, *v.* p. 116

B = C_3H_8O, *n*-Propyl alcohol [30]; *v. also* p. 116

M_A	M_B	Range, °C	c_m
0.25	0.75	65–17	2.574
0.5	0.5	65–18	2.532
0.75	0.25	64–16	2.526

B = C_6H_7N, Aniline, 25°C [21]

% B	0	10	20	30	40	50
c	2.532	2.53	2.52	2.51	2.49	2.46
% B	60	70	80	90	100	
c	2.42	2.37	2.28	2.14	2.026	

C_2Cl_6

B = C_7H_8, Toluene [46]

M_B/M_A	7.5	10	15	20	40
c_m, 18–60°	1.52	1.58	1.63	1.66	1.71

$C_2H_4Cl_2$

Ethylene chloride

B = C_6H_6, Benzene [52]

% A	20°C	35°C	50°	% A	20°C	35°C	50°C
0	1.765	1.986	2.206	60	1.457	1.564	1.671
10	1.715	1.92	2.119	70	1.408	1.495	1.583
20	1.667	1.85	2.031	80	1.357	1.426	1.494
30	1.614	1.77	1.940	90	1.307	1.356	1.406
40	1.561	1.71	1.849	100	1.258	1.287	1.316
50	1.508	1.636	1.760				

$C_2H_4O_2$

Acetic acid

B = $C_3H_6O_3$, Lactic acid [30]

M_A	M_B	Range, °C	c_m
0.5	0.5	65–14	2.243

B = $C_4H_8O_2$, Isobutyric acid [30]

0.49	0.51	65–18	2.042

B = $C_3H_8O_3$, Glycerol, *ca.* 20°C [34]

%	5.3	2.75	1.4
c	2.497	2.497	2.500

C_2H_6O

Ethyl alcohol

B = C_3H_8O, *n*-Propyl alcohol

A = 99.6%; equimolal mixture [19]; *v. also* p. 116

T, °K	80	90	95	98	110	200	260	270
c	0.985	1.09	1.26	1.66	2.00	1.88	2.15	2.20

B = C_6H_6, Benzene, 15°C [61]; *v. also* p. 116

% B	0	10	20	30	40	50
c	2.424	2.392	2.35	2.32	2.274	2.23
% B	60	70	80	90	100	
c	2.175	2.108	2.03	1.91	1.70	

B = $C_6H_6O_2$; A = 90%; *ca.* 20°C [35]

B	0.8%B	0.6%B
Hydroquinol	2.13	2.18
Pyrocatechol	2.19	2.15
Resorcinol	2.22	2.10

B = C_6H_7N, Aniline, *v.* p. 116

C_3H_6O

Acetone

B = $C_4H_{10}O$, Ethyl ether (52)

% A	−40°C	−20°C	0°C	+20°C
0	2.0115	2.1044	2.1797	2.2538
10	1.946	2.042	2.139	2.228
20	1.879	1.986	2.099	2.204
30	1.819	1.933	2.05	2.180
40	1.766	1.883	2.01	2.156
50	1.728	1.846	1.977	2.138
60	1.707	1.825	1.956	2.126
70	1.707	1.822	1.946	2.119
80	1.735	1.846	1.961	2.121
90	1.821	1.917	2.02	2.14
100	1.988	2.0560	2.123	2.1912

B = C_6H_5ClO, *o*-Chlorophenol, 0−20°C (8)

% B	0	10	20	30	40	50
c_m	2.0925	2.042	1.978	1.938	1.892	1.856
% B	60	70	80	90	100	
c_m	1.828	1.795	1.765	1.72	1.678	

B = C_6H_6, Benzene (52)

% A	10°C	30°C	50°C	% A	10°C	30°C	50°C
0	1.619	1.9120	2.2055	60	1.833	2.013	2.184
10	1.645	1.917	2.197	70	1.884	2.045	2.194
20	1.674	1.928	2.187	80	1.952	2.087	2.203
30	1.705	1.941	2.180	90	2.044	2.143	2.224
40	1.742	1.960	2.176	100	2.157	2.216	2.266
50	1.786	1.984	2.177				

$C_3H_6O_2$

Methyl acetate

B = $C_4H_8O_2$, Ethyl acetate (30)

M_A	M_B	Range, °C	c_m
0.5	0.5	55–16	1.833

C_3H_8O

n-Propyl alcohol

B = C_6H_7N, Aniline (30)

0.8	0.2	65–23	2.771
0.35	0.65	65–22	2.478

B = $C_6H_{12}O_2$, Isoamyl formate (30)

0.742	0.258	65–19	1.946
0.3	0.7	65–18	1.976

$C_3H_8O_3$

Glycerol

B = C_6H_7N, Aniline (34); *v. also* p. 116

M_B/M_A	12.5	25	50	100
c_m, 14–16°C	2.271	2.225	2.195	2.1825

$C_4H_5Cl_3O_2$

Ethyl trichloracetate

B = $C_4H_8O_2$, Ethyl acetate (30)

M_A	M_B	Range, °C	c_m
0.25	0.75	54–17	1.707
0.5	0.5	54–15	1.39
0.75	0.25	54–16	2.176

$C_4H_8O_2$

Ethyl acetate

B = $C_6H_{12}O_2$, Isoamyl formate (30)

M_A	M_B	Range, °C	c_m
0.5	0.5	65–16	2.197

B = $C_7H_{14}O_2$, Isoamyl acetate (30)

M_A	M_B	Range, °C	c_m
0.49	0.51	65–17	2.16

B = $C_9H_{10}O_2$, Ethyl benzoate (30)

0.5	0.5	55–17	1.582

$C_4H_{10}O$

Ethyl ether

B = $C_6H_5NO_2$, Nitrobenzene, 20°C (21)

% B	0	10	20	30	40	50
c	2.260	2.173	2.100	2.000	1.940	1.860
% B	60	70	80	90	100	
c	1.770	1.672	1.590	1.512	1.431	

% B (52)	5°C	20°C	35°C	% B (52)	5°C	20°C	35°C
0	2.1977	2.2538	2.3096	60	1.404	1.413	1.476
10	2.024	2.065	2.147	70	1.356	1.361	1.392
20	1.866	1.900	1.987	80	1.352	1.335	1.356
30	1.720	1.747	1.833	90	1.388	1.345	1.362
40	1.593	1.620	1.695	100	1.5248	1.455	1.4075
50	1.487	1.504	1.578				

B = C_6H_6, Benzene (52) *v. also* p. 116

% A	0	10	20	30	40	50
c, 6°	1.559	1.772	1.887	1.953	1.999	2.039
c, 20°	1.765	1.901	1.994	2.052	2.101	2.135
% A	60	70	80	90	100	
c, 6°	2.075	2.106	2.140	2.171	2.201	
c, 20°	2.165	2.190	2.214	2.236	2.2536	

B = C_6H_7N, Aniline (21)

% B	0	10	20	30	40	50
c, 20°	2.260	2.26	2.25	2.23	2.21	2.185
% B	60	70	80	90	100	
c, 20°	2.16	2.12	2.07	2.03	1.975	

C_5H_5N

Pyridine

B = C_6H_5ClO, *o*-Chlorophenol (8)

% B	0	10	20	30	40	50
c, 0–20°	1.653	1.626	1.60	1.58	1.571	1.580
c, 0–100°	1.720	1.712	1.708	1.709	1.717	1.739
% B	60	70	80	90	100	
c, 0–20°	1.634	1.670	1.702	1.71	1.678	
c, 0–100°	1.765	1.775	1.758	1.720	1.657	

B = C_7H_8O, *o*-Cresol (8)

% B	0	10	20	30	40	50
c_m, 0–20°	1.653	1.658	1.673	1.693	1.720	1.755
% B	60	70	80	90	100	
c_m, 0–20°	1.806	1.870	1.942	2.016	2.088	

B = C_7H_8O, *m*-Cresol, (8)

% A	0	10	20	30	40	50
c_m, 0–20°	1.653	1.656	1.668	1.686	1.707	1.734
% A	60	70	80	90	100	
c_m, 0–20°	1.766	1.807	1.863	1.920	2.005	

$C_6H_4Br_2$

p-Dibromobenzene

B = C_7H_8, Toluene (46)

M_B/M_A	7.5	10	15	20	40
c_m, 19–60°	1.52	1.57	1.63	1.66	1.71

C_6H_5Br

Bromobenzene

B = C_6H_5Cl, Chlorobenzene (62)

M_B	M_A		20°	40°	60°	80°
1.00	0.00	c	1.294	1.3195	1.3637	1.425
0.75	0.25	c	1.1727	1.198	1.243	1.3016
0.50	0.50	c	1.0796	1.109	1.1426	1.1987
0.25	0.75	c	1.020	1.041	1.0734	1.114
0.00	1.00	c	0.9648	0.975	0.996	1.025

M_A	M_B	Range, °C	c_m (30)
0.20	0.80	65–17	1.302
0.675	0.325	65–18	1.151

C_6H_5ClO

o-Chlorophenol

B = $C_8H_{11}N$, Dimethylaniline (8)

% A	0	10	20	30	40	50
c_m, 0–20°	1.7495	1.791	1.825	1.855	1.895	1.940
% A	60	70	80	90	100	
c_m, 0–20°	1.955	1.930	1.887	1.810	1.678	

B = C_9H_7N, Quinoline (8)

% A	0	10	20	30	40	50
c_m, 0–20°	1.473	1.465	1.473	1.510	1.550	1.600
% A	60	70	80	90	100	
c_m, 0–20°	1.667	1.702	1.707	1.69	1.678	

C_6H_5I

Iodobenzene

B = C_6H_7N, Aniline (46)

M_B/M_A	2.5	5	10	15	20
c_m, 19–60°	1.504	1.708	1.864	1.93	1.97

$C_6H_5NO_2$

Nitrobenzene

B = C_6H_6, Benzene (52)

% A	10°C	30°C	50°C	75°C
0	1.6186	1.9120	2.2055	2.5735
10	1.545	1.816	2.084	2.428
20	1.480	1.720	1.966	2.282
30	1.418	1.628	1.846	2.139
40	1.365	1.553	1.734	2.007
50	1.322	1.481	1.625	1.876
60	1.289	1.413	1.528	1.749
70	1.277	1.373	1.464	1.652
80	1.305	1.352	1.405	1.547
90	1.366	1.357	1.373	1.454
100	1.4990	1.4200	1.3804	1.3920

B = C_6H_7N, Aniline (30)

M_A	M_B	Range, °C	c_m
0.75	0.25	65–13	1.53
0.75	0.25	98–15	1.574
0.5	0.5	65–15	1.689
0.5	0.5	98–18	1.607
0.25	0.75	65–15	1.883

B = C_7H_9N, Methylaniline (30)

0.43	0.57	65–17	1.695

B = $C_8H_{11}N$, Dimethylaniline (30)

0.46	0.54	65–18	1.707

B = $C_8H_{11}N$, Ethylaniline (30)

0.49	0.51	65–16	1.699

B = $C_{10}H_{15}N$, Diethylaniline

M_A	M_B	Range, °C	c_m
0.5	0.5	65–19	1.771

C_6H_6

Benzene

B = C_7H_8, Toluene (62)

M_A	M_B		20°C	30°C	40°C	50°C	60°C
1.00	0.00	c	1.706	1.722	1.762	1.824	1.915
0.95	0.05	c	1.698	1.719	1.7596	1.8165	1.892
0.875	0.125	c	1.711	1.720	1.756	1.811	1.885
0.75	0.25	c	1.702	1.733	1.766	1.807	1.864
0.50	0.50	c	1.682	1.712	1.744	1.781	1.827
0.25	0.75	c	1.663	1.692	1.724	1.7596	1.801
0.00	1.00	c	1.6407	1.671	1.701	1.735	1.7714

M_A	M_B	Range, °C	c_m (30)
0.5	0.5	55–15	1.666

B = C_7H_8O, *m*-Cresol (30)

0.54	0.46	65–18	2.051

B = C_8H_{10}, *m*-Xylene (30)

0.5	0.5	55–15	1.576

C_7H_8

Toluene

B = $C_{10}H_7Br$, β-Bromonaphthalene (46)

M_A/M_B	1	5	10	20
c_m, 22–60°	1.29	1.55	1.64	1.70

B = $C_{10}H_8$, Naphthalene (46)

M_A/M_B	5	10	20
c_m, 20–50°	1.695	1.72	1.736

C_7H_8O

m-Cresol

B = C_7H_9N, *o*-Toluidine (30)

M_A	M_B	Range, °C	c_m
0.75	0.25	64–14.5	1.783
0.5	0.5	64.5–14	2.051
0.25	0.75	64–15	2.03

B = $C_8H_{11}N$, Dimethylaniline (30)

0.53	0.47	65–17	1.825
0.5	0.5	54–17	1.887

C_8H_{10}

o-Xylene

B = C_8H_{10}, *m*-Xylene (30)

M_A	M_B	Range, °C	c_m
0.269	0.731	64–19	1.786
0.729	0.271	65–20	1.808

B = C_8H_{10}, *p*-Xylene

0.815	0.185	65–16	1.754
0.32	0.68	64–20	1.825

C_8H_{10}

m-Xylene

B = C_8H_{10}, *p*-Xylene (30)

M_A	M_B	Range, °C	c_m
0.754	0.246	65–18	1.674
0.293	0.708	65–17	1.724

B = $C_8H_{11}N$, Dimethyaniline (30)

0.734	0.266	65–19	1.707
0.287	0.713	65–18	1.808

THREE-COMPONENT SYSTEMS

$H_2O + H_2SO_4 + HNO_3$, t = 20°C (45); *v.* Fig. 3

% H_2O	H_2SO_4	HNO_3	c	% H_2O	H_2SO_4	HNO_3	c
10	45	45	1.887	15	70	15	1.84
20	40	40	2.12	30	10	60	2.55
40	30	30	2.545	50	10	40	2.74
50	25	25	2.745	75	10	15	3.37
60	20	20	2.93	40	40	20	2.45
75	12.5	12.5	3.51	10	80	10	1.76
85	7.5	7.5	3.8	5	5	90	2.00
10	10	80	2.13	2.5	70	27.5	1.67
10	30	60	1.97	5	25	70	1.92
10	50	40	1.88				

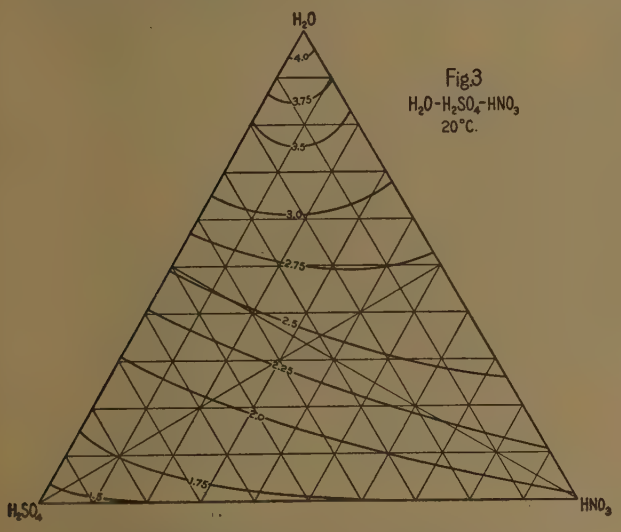


Fig.3
H_2O-H_2SO_4-HNO_3
20°C.

$H_2O + C_2H_5OH$ + a salt, t = *ca.* 20°C; *v. also* p. 116

Salt	Moles C_2H_5OH per 200 moles H_2O + 1 mole salt							Lit.
	100	50	40	35	30	15	10	
NaCl	3.632*	4.072	4.152	4.160†	4.243	4.264‡	4.231	(26)
KCl	3.574	3.984	4.126	4.156	4.206	4.236		(27)
$NaNO_3$	3.616	4.021	4.126	4.160	4.206	4.248		(27)
KNO_3	3.591	4.021	4.122	4.126	4.193	4.649	4.185	(27)
NaBr			4.093					(28)
KBr			4.072					(28)
NaI			4.05					(28)
KI			4.024					(28)

* For C_2H_5OH = 200 moles, c = 3.277.
† C_2H_5OH = 33.33 moles.
‡ C_2H_5OH = 20 moles.

$H_2O + C_2H_5OH + x$ (29); 80 moles C_2H_5OH + 200 moles H_2O + 1 mole x, t = *ca.* 18°C

x	$C_3H_8O_3$, Glycerol	C_6H_6O Phenol	$C_{12}H_{22}O_{11}$, Sucrose	Tannic acid (Digallic?)
c	4.120	4.168	4.1225	(4.10)

$H_2O + C_{12}H_{22}O_{11} + NaCl$, t = 21.4°C (4)

H_2O, moles	NaCl		$C_{12}H_{22}O_{11}$		c
	Moles	%	Moles	%	
200	1	1.59	0	0	4.0865
	0.75	1.17	0.25	2.29	4.054
	0.5	0.768	0.5	4.498	4.027
	0.25	0.378	0.75	6.62	3.991
	0	0	1	8.67	3.969
100	1	3.14	0	0	4.008
	0.75	2.29	0.25	4.47	3.957
	0.5	1.46	0.5	8.55	3.908
	0.25	0.702	0.75	12.38	3.854
	0	0	1	15.95	3.796
50	1	6.09	0	0	3.8825
	0.75	4.26	0.25	8.30	3.778
	0.5	2.66	0.5	15.53	3.685
	0.25	1.26	0.75	21.23	3.605
	0	0	1	27.55	3.522
25	1	11.48	0	0	3.678
	0.75	7.56	0.25	14.76	3.500
	0.5	4.49	0.5	26.30	3.364
	0.25	2.05	0.75	36.06	3.260
	0	0	1	43.23	3.163

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(For a key to the periodicals see end of volume)

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THERMAL EFFECTS ACCOMPANYING PHYSICAL AND CHEMICAL PROCESSES

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LATENT HEATS OF FUSION

R. de Forcrand and L. Gay

Scope of the Tables.—The data given in the following tables are based solely upon the best available direct calorimetric determinations and do not take into account the values, sometimes more reliable, which can be computed by indirect methods. For such values the reader should consult the appropriate sections of I. C. T. as indicated in the index under, "Fusion, heat of."

Calorimetric Methods. *A.*—m grams of the pure substance which has been in the crystalline state for a long period of time (hereafter referred to as the "stable" crystalline form) is taken at a temperature slightly below its fusion point t_F and is introduced into a calorimeter, the temperature of which is slightly above t_F. The final state of the substance is liquid. The total effect produced is composed of (*a*) the heat absorbed by the solid up to t_F, (*b*) the heat absorbed by the liquid between t_F and the final temperature, and (*c*) the heat of fusion. Knowing the two specific heats, the heat of fusion, L_F, at the M. P., is obtained by difference.

B.—As in Method *A*, but in the reverse order, the liquid substance slightly above its fusion point is introduced into the calorimeter, where it crystallizes. This experiment gives directly the heat of solidification, L_D, rather than the heat of fusion, L_F. The heat of solidification is sometimes less than the heat of fusion, because at the moment of solidification the substance does not always liberate its entire heat of fusion. The determination of L_F is therefore preferable.

C.—Two samples of the pure substance are employed, one in the "stable" crystalline form, the other in the form of the supercooled liquid, and both at the same temperature, which is substantially that of the calorimeter. In two separate experiments the substance is brought to the same final state which may be anything, but is the same for the two samples. The difference between the two values found gives directly the heat of fusion. In this case there is no difference between L_F and L_D if the crystalline sample employed is in the "stable" form. In most cases the final state in such an experiment is a solution in the calorimetric liquid, but obviously it might be any state. The value finally obtained by Method *C* is the heat of fusion at the temperature of

the calorimeter and is identical with the heat of fusion at the melting point only in case the calorimeter is operated in the neighborhood of this temperature.

D.—The super-cooled substance is maintained in the calorimeter until temperature equilibrium is secured, and crystallization is then produced by seeding. This method gives L_D.

E.—In this method (Wigand) the "stable" crystalline substance is melted in the calorimeter by means of a measured amount of electrical energy. This method gives L_F directly, but requires a calorimetric liquid with a melting point lower than t_F.

F.—The method of thermo-analysis (W. Plato) gives reliable results in cases where L_F is known for an analogous substance having approximately the same melting point. The method is a relative one.

G.—In the method of L. Meyer, a Bunsen calorimeter is employed, the calorimetric liquid being the pure substance at its melting point. The determination consists in measuring the variation in volume, ΔV, which accompanies the fusion of 1 g of the substance. In a second experiment, a known quantity of heat Q is introduced into the calorimeter electrically and the accompanying volume change $\Delta V'$ is measured. $\Delta V'/\Delta V$ gives the mass m of the substance melted. The heat of fusion is then

$$\frac{Q}{m} = \frac{Q}{\Delta V'}\Delta V.$$

The temperature t_F being constant, a knowledge of the specific heats is unnecessary.

H.—Special methods, for which see the literature cited.

I.—Method not given by the author.

Conversion Factors.—1 Kilojoule per g = 238.9 cal_{15} g^{-1} = 430.1 BTU_{60} $lb.^{-1}$ = 9.869 l-atm. g^{-1} = 2.778 × 10^{-4} kw hr g^{-1}. For other factors, *v.* Vol. I, p. 24.

Non-Metallic Elementary Substances*

Formula	M. P., °C	Joule per g	Kilojoule per g-atom	Method	Lit.
A	−190	28.1	1.12	*A*	(18)
O	−219	13.8	0.221	*A*	(18)
H		63 ± 6	0.063	*E*	(42)
		58.6 ± 0.3	0.0591	*A*	(70)
Cl	−103.5	96.1	3.40₈	*A, E*	(17, 18.5)
Br	− 7.32	67.7 ± 0.7	5.41₀	*A*	(62)
S	115	39.21₅	1.257	*B*	(54)
	118.95	43.6 ± 1.2	1.40	*E*	(84)
	119	55.2	1.77	*B*	(40)
		37.05	1.188	*E*	(74)
Te	446				(90)
N	−210	25.5	0.36	*A*	(18)
P	44.2	21.07	0.6538	*B*	(54)

* For heats of fusion of metallic elementary substances, *v.* Vol. II, p. 458.

ℬ-Table.—Chemical Compounds (Standard Arrangement)

(*v.* Vol. III, p. viii)

Formula	M. P., °C	Joule per g	Kilojoule per g-formula-wt.	Method	Lit.
H_2O	0	333.6±0.33	6.0099	*E*	(14.1)
H_2O_2	−1.7	310±1.25	10.5±0.04	*A*	(47)
HBr	−86	32.1	2.60	*E*	(18.5)
	−86.8	29.7	2.41	*E*	(87)
HCl	−114	58	2.11	*E*	(18.5)
	−114	54.6	1.99	*E*	(86)
$HCl.2H_2O$	−18.5	144.6₅	10.48₅	*C*	(8)
HI	−53	23.7₈	3.04	*E*	(18.5)
$ICl_{(\alpha)}$	27.2	68.75±1.0	11.16±0.16	*A*	(73)
$ICl_{(\beta)}$	15.2±1.3	58.6 ±0.65	9.52±0.1	*C, A*	(6, 73)
SO_3	−30	99.4	7.96	*C*	(20)
H_2SO_4	10.352	100.6±0.7	9.865±0.07	*A*	(87)
H_2SO_4.—(*Cont'd*)		95.5	9.3₆	*A*	(43)
	10.49	108.7₅	10.66₅	*A*	(11)
$H_2SO_4.H_2O$	8.56*	163.6±3.0	19±0.35	*A*	(11, 46, 57)
$H_2S_2O_7$	35	75.0±4	1.35	*D*	(1.5)
NO	−163	77	2.32	*E*	(18.5)
N_2O_4	−10.14	135 to 155.5	12.4 to 14.35	*A*	(61)
N_2O_5	29.5?	320.9₅?	34.66₅?	*I*	(3)
NH_3	−75	452.5	7.7	*A*	(49)
	−77.6	351	5.9₈	*E*	(18.5)
HNO_3	−47	39.9₅	2.51₅	*C*	(3)
H_3PO_2	17.4	146.5	9.68	*C*	(78)
$POCl_3$	2	83	12.7	*A*	(81)
$AsBr_3$	31	37.4	11.75	*B*	(79)
$SbCl_3$	73.2	55.6₅	12.69	*B*	(79)
$SbBr_3$	94	40.8₅	14.77	*B*	(79)
Sb_2S_3	540	73.5	24.9	*B*	(35, 41)
CO	−206	33.5	0.094	*A*	(18)
CO_2	−56.2	189.6	8.35	*A*	(47.5)
	For other C-compounds, *v.* ℭ-Table				
$SiCl_4$	70.3	45.4₂	7.7₅	*E*	(44)
$TiCl_4$	−25	49.2₇	9.348	*E*	(44)
$SnCl_4$	−33	35.16±0.8	9.160	*E*	(44)
$SnBr_4$	25.5	26.2±0.1	11.5	*B, C*	(5, 79)
$PbCl_2$	485	87.5±1.8	24.3	*B*	(16)
				F	(58)
	498	77.5	21.5	*B*	(31)
$PbBr_2$	490	51.65±1.5	18.96±0.55	*B*	(16)
	488	41.5	15.2	*B*	(31)
PbI_2	375	48.1±1.2	22.2±0.55	*B*	(16)
TlCl	427	69.5	16.7	*B*	(31)
TlBr	460	53	15.1	*B*	(31)
$TlOC_2H_5$		4.4	1.1	*C*	(26.5)
$Zn(NO_3)_2.6H_2O$	36.4	130	38.6	*B*	(63)
$Cd(NO_3)_2.4H_2O$	59.5	106	32.7	*B*	(63)
$HgBr_2$	235	53.6	19.32	*B*	(34)
HgI_2	250	41	18.6	*H*	(33)
$Cu(NO_3)_2.6H_2O$	24.4	123	36.4	*B*	(63)
AgCl	451	128.5	18.4	*B*	(64)
	455	89	12.8	*B*	(31)
AgBr	430	52.5	9.9	*B*	(31)
$AgNO_3$ *cf.*(89)	208	74.25±0.75	12.6±0.1	*H*	(33)
	218	63.5	10.8	*B*	(31)
OsO_4	40.1	56.6±1	14.4±0.2	*G*	(81.5)
$Mn(NO_3)_2.6H_2O$	25.8	120.5	34.6	*B*	(63)
$Co(NO_3)_2.6H_2O$		126.5	36.8	*B*	(63)
$Ni(NO_3)_2.6H_2O$	56.7	152.5	44.3	*B*	(63)
$MgCl_2.6H_2O$	116.7	172.5	35.1	*B*	(63)
$Mg(NO_3)_2.6H_2O$	90	160	41	*B*	(63)
$CaCl_2$	773.9	227.15±1.35	25.21±0.14	*F*	(58, 67)
$CaCl_2.6H_2O$	29±0.5	170.5	37.3	*B*	(55)
$Ca(NO_3)_2.4H_2O$	42.1±0.1	142.2±2.2	33.6±0.5	*A*	(57)
				I	(76)
$SrCl_2$	872.3	106.5±0.5	16.85±0.05	*F*	(58)
$BaCl_2$	958.9	115	24	*F*	(58)
$LiNO_3$	250	370.5	25.5₅	*B*	(31)
Li_2SiO_3		335.5	30.2	*F*	(68)
$Li_2SiO_3.Li_2O$		260	31.1	*F*	(68)
NaOH	318.4	167.5	6.7	*F*	(37)
NaF	992.2	779	32.71	*F*	(58.1)
NaCl	804.3	517	30.2	*F*	(58)
$NaClO_3$	255	205.0±2.5	21.825±0.27	*B*	(23, 31)
$Na_2SO_4.10H_2O$	31	214.5	69	*B*	(12)
	31.5	239	77.0	*B*	(45)
$Na_2S_2O_3.5H_2O$		200.0±0.5	49.65±0.15	*B*	(45)
$NaNO_3$	333	189.5	16.1	*B*	(31)
$Na_2HPO_4.12H_2O$	36.1	279.5	100.1	*B*	(55)
$Na_2CrO_4.10H_2O$	23 to 30	164.0 to 150.8	56.12 to 51.59	*C*	(5)
KOH	360.4	119.5	6.72	*F*	(37)
KF	859.9	452	26.3	*F*	(58.1)
KCl	772.3	310±50	23.1±3.7	*F*	(58)
KNO_3	308	106.5	10.8	*B*	(31)
$K_2Cr_2O_7$	397	124.5	36.7	*B*	(31)
RbOH	301	66	6.7₅	*F*	(37)
RbCl		159	19.2	*F*	(58)
CsOH	272.3	45	6.7	*F*	(37)

* ±0.06.

C-Table

The C-Arrangement (*v.* Vol. III, p. viii)

Formula	Name	M. P., °C	Joule per g	Kilojoule per g-formula-wt.	Method	Lit.
CCl_4	Carbon tetrachloride	−24	17.4 ± 0.25	2.68	*E*	(44)
CH_2N_2	Cyanamide	42.9	208.5 ± 3	11.27	*B*	(60)
CH_2O_2	Formic acid	8.0 ± 0.6	246.5 ± 1.9	11.34	*A, B*	(32, 56)
CH_4	Methane	−182.6	60.8	0.974	*E*	(18.5)
CH_4O	Methyl alcohol	−97	68.6	2.20	*A*	(48)
		−97.8	92.2	2.95	*E*	(53.5)
$C_2HCl_3O_2$	Trichloroacetic acid	59.1	36	5.9	*B*	(57)
$C_2H_2Cl_2O_2$	Dichloroacetic acid	10.8	59.5	7.65	*B*	(57)
$C_2H_2Br_2O_2$	Bromal hydrate	46	70.75	21.15	*B*	(10)
$C_2H_3ClO_2$	Chloroacetic acid (α)	61.2	130	12.3	*B*	(57)
	Chloroacetic acid (β)	56	147	13.8	*B*	(57)
$C_2H_3Cl_3O_2$	Chloral hydrate		138.9	22.97	*C*	(4)
$C_2H_4Br_2$	Ethylene dibromide	9.55	56.62	10.637	*B*	(14)
$C_2H_4O_2$	Acetic acid	16.58 ± 0.04	187.1 ± 6.7	11.23	*B**	(46, 56)
		16.7	181	10.9	*E*	(53.7)
C_2H_6O	Ethyl alcohol	−114.4	104.2 ± 3.7	4.80	*A, E*	(29, 53.5)
$C_2H_6O_2$	Glycol	−11.5	181.1	11.24	*A*	(24)
		−12.3	174	10.8	*E*	(53.5)
$C_3H_4O_2$	Acrylic acid	13	155	11.2	*I*	(66)
$C_3H_5N_3O_9$	Trinitroglycerol	12.3	96.35	21.88	*B*	(52)
	Stable form		21.8†	4.95†	*D*	(38)
	Metastable form	13	138.9†	31.5†	*D*	(38)
C_3H_6O	Acetone	−95.5	98	5.69	*E*	(53.7)
		−94.6	82	4.76	*B*	(48)
$C_3H_7NO_2$	Urethane	48.7	171	15.2	*B*	(19)
C_3H_8O	Isopropyl alcohol	−88.5	88	5.34	*E*	(53.7)
$C_3H_8O_3$	Glycerol	18	198.8	18.3	*B*	(28)
$C_4H_4N_2$	Succinonitrile	54.5	49	3.92	*I*	(76)
$C_4H_4O_3$	Succinic anhydride	119	204	20.4	*I*	(76)
$C_4H_6O_2$	Crotonic acid$_{(\alpha)}$	67.4	106.0	9.11	*B*	(10)
	Crotonic acid$_{(\alpha)}$	71.4	152.4 ± 4	13.1	*B*	(46.5)
	Crotonic acid$_{(cis)}$	71.23	146.15	12.575	*B*	(9.1)
$C_4H_6O_4$	Methyl oxalate	49.5	178.5	21.05	*B*	(10)
$C_4H_7Cl_3O_2$	Chloral alcoholate	9	100.6	19.455	*C*	(7)
$C_4H_8N_2S$	Thiosinamine	77	140	16.25	*B*	(89)
$C_4H_8O_2$	*n*-Butyric acid	−5.7	126	11.1	*E*	(53.6)
$C_4H_{10}O$	*n*-Butyl alcohol	89.2	125.3 ± 0.2	9.280	*E*	(53.5)
	tert.-Butyl alcohol	25.45	87.8	6.505	*C*	(25)
	tert.-Butyl alcohol	25.4	91.6	6.78	*E*	(53.6)
$C_5H_8O_3$	Levulinic acid	33	79.4	9.215	*C*	(8)
$C_5H_8O_4$	Glutaric acid	99.3	156.5	20.65	*B*	(36)
$C_5H_{12}O$	*tert.*-Amyl alcohol		52.5	4.65	*I*	(76)
$C_6H_3Br_3O$	2, 4, 6-Tribromophenol	93	56	18.55	*B*	(89)
C_6H_4BrCl	*o*-Bromochlorobenzene	−12.6	64.5	12.35	*I*	(51)
	m-Bromochlorobenzene	−21.2	64	12.25	*I*	(51)
	p-Bromochlorobenzene	64.6	98	18.75	*I*	(51)
C_6H_4BrI	*o*-Bromoiodobenzene	21	51	14.45	*I*	(51)
	m-Bromoiodobenzene	−9.3	43	12.2	*I*	(51)
	p-Bromoiodobenzene	90.1	69.5	19.65	*I*	(51)
$C_6H_4Br_2$	*o*-Dibromobenzene	18	53.5	12.6	*I*	(51)
	m-Dibromobenzene	−6.9	56	13.2	*I*	(51)
	p-Dibromobenzene	86 ± 1	86 ± 1	20.3	*B*‡	(9, 10)
$C_6H_4Br_2O$	2, 4-Dibromophenol	12	58.5	14.75	*C*	(83)
$C_6H_4Br_3N$	2, 4, 6-Tribromoaniline	122	70.5	23.25	*B*	(64)
$C_6H_4ClNO_2$	*m*-Chloronitrobenzene	43.8	123	19.4	*B*	(10)
		44.16	131.9	20.775	*B*	(9)
	p-Chloronitrobenzene	82	89.5	14.1	*B*	(10)
$C_6H_4Cl_2$	*o*-Dichlorobenzene	−17.5	88	12.9	*I*	(51)

* Also *C* (25, 80) and *G* (50). † Heat of crys. at 0°. ‡ Also *I* (51).

Formula	Name	M. P., °C	Joule per g	Kilojoule per g-formula-wt.	Method	Lit.
$C_6H_4Cl_2$	*m*-Dichlorobenzene	−24.4	86	12.6	*I*	(51)
	p-Dichlorobenzene	52.7 ± 0.2	124.2 ± 0.8	18.25	*B*	(10)
					I	(51)
$C_6H_4I_2$	*o*-Diiodobenzene	23.4	42.5	14.1	*I*	(51)
	m-Diiodobenzene	34.2	48.35	15.95	*I*	(51)
	p-Diiodobenzene	129	67.8	22.4	*I*	(51)
$C_6H_4N_2O_4$	*o*-Dinitrobenzene	116.93	135.0 ± 4	22.84	*B*	(1.4)
	m-Dinitrobenzene	90.08	103.4 ± 4	17.36	*B*	(1.4)
	p-Dinitrobenzene	173.5	167.4 ± 4	28.1	*B*	(1.4)
$C_6H_4O_2$	Quinone	112.85 ± 0.5	171.0 ± 4	18.46	*B*	(46.5)
C_6H_5BrO	*p*-Bromophenol	64	85.8 ± 1.3	14.85	*C*	(83)
$C_6H_5NO_2$	Nitrobenzene	5.72 ± 0.10	94.25 ± 0.25	11.6	*G, I*	(50, 76)
$C_6H_5NO_3$	*o*-Nitrophenol	42.8	112	15.6	*B*	(10)
		44.51	129.35	17.98	*B*	(9)
C_6H_6	Benzene	5.42 ± 0.02	127.0 ± 1.4	9.91	*A**	(9, 14)
						(22, 48)
		5.40	126.5 ± 4	9.88	*B*	(1.4)
C_6H_6ClN	*p*-Chloroaniline	69	155.5	19.83	*B*	(10)
$C_6H_6N_2O_2$	*o*-Nitroaniline	69.3	116.7	16.12	*B*	(1.4)
	m-Nitroaniline	111.8	171.5	23.70	*B*	(1.4)
	p-Nitroaniline	147.5	152.6	21.10	*B*	(1.4)
C_6H_6O	Phenol	25.37	121.5	11.4	*E*	(74)
$C_6H_6O_2$	*o*-Dihydroxybenzene	104.3	206.8	22.76	*B*	(1.4)
	m-Dihydroxybenzene	109.65 ± 0.5	193.4	21.29	*B*	(1.4, 67)
	p-Dihydroxybenzene	172.3	246.0	21.70	*B*	(1.4)
C_6H_7N	Aniline	−7.03	87.7	8.16	*A*	(25)
$C_6H_8N_2$	Phenylhydrazine	22.1	152.0 ± 0.6	16.43	*A*	(46)
$C_6H_8O_4$	Methyl fumarate	102	242.5	34.95	*B*	(53)
$C_6H_{10}O_4$	Methyl succinate	18	149.55	21.84	*B*	(53)
$C_6H_{10}O_6$	*dl*-Dimethyl tartrate	87	147	26.2	*F*	(77)
	d-Dimethyl tartrate	49	90	16	*F*	(77)
$C_6H_{12}O$	Cyclohexanol	23.2 ± 0.8	17.55 ± 0.3	1.756	*B, C*	(26, 85)
$C_6H_{12}O_3$	Paraldehyde	12.6	104.75	13.83	*A*	(46)
$C_7H_5ClO_2$	*o*-Chlorobenzoic acid	140.2	164.5 ± 4	25.76	*B*	(46.5)
	m-Chlorobenzoic acid	154.25	152.4 ± 4	23.86	*B*	(46.5)
	p-Chlorobenzoic acid	239.7	206 ± 4	32.3	*B*	(46.5)
$C_7H_5NO_4$	*o*-Nitrobenzoic acid	145.8	167.7 ± 4	28.02	*B*	(46.5)
	m-Nitrobenzoic acid	141.1	115.5 ± 4	19.30	*B*	(46.5)
	p-Nitrobenzoic acid	239.2	221.0 ± 4	36.90	*B*	(46.5)
$C_7H_5N_3O_6$	2, 4, 6-Trinitrotoluene	79	93.5 ± 3.5	21.23	*I*	(14.2, 76)
$C_7H_6N_2O_4$	2, 4-Dinitrotoluene	70	110.5	20.1	*I*	(76)
$C_7H_6O_2$	Benzoic acid	121.8	141.9 ± 4	17.3	*B*	(46.5)
C_7H_7Br	*p*-Bromotoluene	27.6 ± 1.2	87.3 ± 3	14.93	*B*	(56)
					A	(46)
C_7H_7I	*p*-Iodotoluene	34	78.5	17.1	*I*	(76)
$C_7H_7NO_2$	*o*-Aminobenzoic acid	145	148.5 ± 4	20.38	*B*	(1.4)
	m-Aminobenzoic acid	180	159.2 ± 4	21.83	*B*	(1.4)
	p-Aminobenzoic acid	188.5	152.6 ± 4	20.91	*B*	(1.4)
C_7H_8O	*p*-Cresol	34	110	11.9	*B*	(10)
$C_7H_8O_2$	Dimethyl-γ-pyrone	132	235	29	*B*	(59)
C_7H_9N	*p*-Toluidine	40.01 ± 0.12	167.0 ± 2.4	17.88	*B*	(2, 14)
$C_8H_6Cl_4$	*o*-Tetrachloroxylene	86	88	21.45	*I*	(13)
	p-Tetrachloroxylene	95	92.5	22.55	*I*	(13)
$C_8H_8Br_2$	*o*-Xylene dibromide	95	101.5	26.79	*I*	(13)
	m-Xylene dibromide	77	89.8	23.7	*I*	(13)
$C_8H_8Cl_2$	*o*-Xylene dichloride	55	121.5	21.25	*I*	(13)
	m-Xylene dichloride	34	111.5	19.55	*I*	(13)
	p-Xylene dichloride	100	137	23.95	*I*	(13)
$C_8H_8O_2$	Phenylacetic acid	74.9	106.5	14.45	*B*	(10)
		76.58	125.6	17.09	*B*	(9)
		77	134	18.2	*B*	(64)

* *Also I*(21), *G*(50), *B*(53), *A*(9).

Formula	Name	M. P., °C	Joule per g	Kilojoule per g-formula-wt.	Method	Lit.
$C_8H_8O_2$	*o*-Toluic acid	103.7	148.2 ± 4	20.18	*B*	(1.4)
	m-Toluic acid	108.75	115.5 ± 4	15.74	*B*	(1.4)
	p-Toluic acid	179.6	167 ± 4	22.71	*B*	(1.4)
$C_8H_9NO_2$	Hydroxyacetanilide	91.3 ± 0.1	140.6	21.26	*B*	(1.4)
C_8H_{10}	*p*-Xylene	16	164.5	17.45	*I*	(13)
$C_8H_{10}O_2$	Veratrol	22.7	114.9 ± 1.25	15.87	*B, A*	(46, 64)
$C_8H_{16}O_2$	*n*-Caprylic acid	16.34	148.2	21.36	*B*	(27)
$C_9H_8O_2$	Allocinnamic acid	58	114.5	17		(65)
$C_9H_8O_2$	Cinnamic acid	133	152.85	22.635	*B*	(53)
$C_9H_{10}O_2$	Hydrocinnamic acid	48	117.75	32.74	*B*	(53)
$C_9H_{18}O_2$	*n*-α-Pelargonic acid	12.35	128.2	20.27	*B*	(27)
	n-β-Pelargonic acid		163.4	25.84	*B*	(27)
$C_{10}H_7NO_2$	α-Nitronaphthalene	56	106.5	18.43	*B*	(2)
$C_{10}H_8$	Naphthalene	79.9 ± 1.1	148.9 ± 0.4	19.07	*B*	(1, 2, 46.5, 53, 57)
$C_{10}H_8O$	α-Naphthol	95	163 ± 4	23.5	*B*	(46.5)
	β-Naphthol	120.6	131 ± 4	18.8	*B*	(46.5)
$C_{10}H_8O_2$	Methyl phenylpropiolate	18	95.75	15.325	*B*	(53)
$C_{10}H_9N$	α-Naphthylamine	47.5	93.5	13.35	*B*	(10)
		48.9	92.05	13.17	*B*	(14)
		50.1	107.1 ± 0.8	15.33	*B*	(71)
$C_{10}H_{10}$	1, 4-Dihydronaphthalene	150	21.85	2.84	*I*	(76)
$C_{10}H_{10}O_2$	Methyl cinnamate	34.5 ± 1.5	111 ± 1.5	17.99	*I, B*	(53, 76)
$C_{10}H_{12}O$	Anethole	21.5	108.0 ± 1.3	16 ± 0.19	*B*	(46)
$C_{10}H_{14}O$	Thymol	48.5	115	17.3	*B*	(19)
$C_{10}H_{15}BrO$	Bromocamphor		174	40.2	*B*	(2)
$C_{10}H_{15}NO$	*d*-Carvoxime	71.5	97.5	16.1	*F*	(77)
	l-Carvoxime	71	98	16.15	*F*	(77)
	dl-Carvoxime	91	103	17.0	*F*	(77)
$C_{10}H_{20}O$	*l*-α-Menthol	42	78 ± 1	12.2	*B*	(10)
$C_{10}H_{20}O_2$	*n*-Capric acid	31.2	162.7	28.01	*B*	(27)
$C_{11}H_{22}O_2$	*n*-Undecylic acid$_{(\alpha)}$	28.25	134.8	25.09	*B*	(27)
	n-Undecylic acid$_{(\beta)}$		179.6	33.43	*B*	(27)
$C_{12}H_9N$	Carbazole	236	176	29.45	*I*	(76)
$C_{12}H_{10}$	Diphenyl	71	109.2 ± 0.6	16.84	*B*	(82)
$C_{12}H_{10}N_2$	Azobenzene	69.1	121	22.1	*B*	(19)
		66	117	21.25	*B*	(10)
		68	135.6	24.69	*B*	(53)
$C_{12}H_{10}N_2O$	Azoxybenzene	34.6	90.5	17.9	*B*	(10)
$C_{12}H_{11}N$	Diphenylamine	53.4 ± 0.6	105.6 ± 5.3	17.86	*B*	(9, 71)
$C_{12}H_{12}N_2$	Hydrazobenzene	134	95.75	17.63	*I*	(76)
$C_{12}H_{14}O_4$	Apiol	29.26	108.0 ± 0.2	23.99	*B*	(75)
$C_{12}H_{24}O_2$	*n*-Lauric acid	43.85 ± 0.15	183 ± 2	36.63	*B*	(72)
					B	(27)
$C_{13}H_{10}O$	Benzophenone	48.25 ± 0.25	98.5 ± 0.55	17.95	*B*	(10, 75)
$C_{13}H_{12}$	Diphenylmethane	26.3	105.5	17.7	*I*	(76)
$C_{13}H_{13}N$	Benzylaniline	36	91.5	16.75	*I*	(76)
$C_{14}H_8O_2$	Anthraquinone	282	156.9 ± 1.2	32.64	*B*	(39)
$C_{14}H_{10}$	Anthracene	216.55	162 ± 0.4	28.85	*B*	(39)
$C_{14}H_{10}$	Phenanthrene	98.2 ± 1.8	101.5 ± 2.5	18.1	*B*	(64)
$C_{14}H_{10}$	Tolane	60	120.05	21.38	*B*	(53)
$C_{14}H_{10}O_2$	Benzil	94.94	92.7	19.45	*B*	(9)
$C_{14}H_{12}$	Dihydrophenanthrene	94	73.45	13.25	*B*	(53)
$C_{14}H_{12}$	Stilbene	124	167	30.2	*I*	(76)
$C_{14}H_{14}$	Dibenzyl	51	129.85	23.645	*I*	(76)
$C_{14}H_{28}O_2$	Myristic acid		198.75	45.35	*B*	(72)
$C_{16}H_{32}O_2$	Palmitic acid	55	164	42.05	*B*	(10)
$C_{16}H_{34}O$	Cetyl alcohol	47	141.5	34.25	*I*	(76)
$C_{18}H_{14}O_3$	Cinnamic anhydride	48	117.75	32.74	*B*	(53)
$C_{18}H_{34}O_2$	Elaidic acid	47	218	61.55	*I*	(76)
$C_{18}H_{36}O_2$	Stearic acid	64	199	56.5	*B*	(10)
$C_{19}H_{16}$	Triphenylmethane	92.3	74.5 ± 0.8	18.2	*B*	(39)
$C_{57}H_{110}O_6$	Tristearin	56	191	170	*I*	(76)

LITERATURE

(For a key to the periodicals see end of volume)

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(90) Umino, *47*, **28**: 381; 28.

LATENT HEAT OF VAPORIZATION

The values recorded in this section are based upon direct calorimetric determinations. For values based upon vapor pressure data, *see* the vapor pressure sections of Vol. III, p. 201, 204, 207, 213, 215, 302, and for metals, *v.* Vol. II, p. 458; Vol. III, p. 204.

CONVERSION FACTORS

1 joule = 0.2392 g-cal$_{20}$; = 0.2389 g-cal$_{15}$; = 2.778×10^{-7} kw. hr; = 0.7376 ft. lb.; = 9.870×10^{-3} l-atm.; = 9.482×10^{-4} BTU$_{60}$.

ELEMENTARY SUBSTANCES AND ATMOSPHERIC AIR*

ARTHUR WHITMORE SMITH

Symbol	*l*, g-cal$_{15}$ per g	*L*, kj per g-atom	At *t*, °C or *p*, mm	Lit.
A	37.6	6.28	−186°	(10, 14)
Br	43.7(?)	14.6(?)	+ 63°	(6, 19)
H_2	108	0.455	−252.8°	(10)
H_2	108	0.455	760 mm	(13)
H_2	109.2	0.460	600 mm	(14)
H_2	110.8	0.467	400 mm	(17)
H_2	112.2	0.473	200 mm	(22)
He	6	0.100	−268.6°	(15, 16)
I_2	24(?)	12.7	+184°	(11)
N_2	47.6	2.790	−195.55°	(1)
N_2	48.3	2.830	−198°	(10)
N_2	49.4	2.900	−202°	(14)
N_2	50.5	2.960	−206°	
N_2	51.6	3.025	−210°	
O_2	50.9	3.410	−182.9°	(1) *
O_2	52.0	3.480	−188°	(2) *
O_2	53.2	3.560	−194°	(10) *
O_2	54.5	3.650	−200°	(13) *
O_2	55.5	3.720	−205°	
P	130	17.0	+287°	(12)
S				(1.5)

* For metals, *v.* Vol. II, p. 458; Vol. III, p. 204.

OXYGEN-NITROGEN MIXTURES UNDER ONE ATMOSPHERE

The quantity recorded below is the difference in heat content between the liquid at its boiling point and a vapor of the same composition at its initial condensation temperature. Accuracy: 0.2 % absolute, 0.1 % relative (7.5).

% O_2 in liq	0	5	10	15	20	25	30
l, joule/g	119.8	201.1	202.4	203.7	204.9	206.2	207.4
% O_2 in liq	35	40	45	50	55	60	65
l, joule/g	208.5	209.5	210.4	211.2	212.0	212.7	213.3
% O_2 in liq	70	75	80	85	90	95	100
l, joule/g	213.7	214.1	214.4	214.4	214.1	213.9	213.4

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(For a key to the periodicals see end of volume)

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CHEMICAL COMPOUNDS

FARRINGTON DANIELS AND J. HOWARD MATHEWS

l_v = latent heat of vaporization, joules per gram, at *t*, °C to produce saturated vapor at *t*°, the liquid being under its own vapor pressure during evaporation.

The values marked with an asterisk (*) were obtained by measuring the heat of condensation. All other values were obtained by measuring the input of electrical energy necessary to evaporate a given weight of liquid.

The results by condensation methods (*) are usually too low on account of premature condensation and are unreliable also, because the specific heat of the liquid is usually not accurately known. Most of the results published before 1900 may be too low by 10 joules or more.

For the substances marked with a dagger (†) the value given is taken from the detailed tables of the next section, p. 138.

Parentheses ( ) around the temperature indicate that the temperature was not recorded in the original communication and that the normal boiling point has been taken. The corresponding value of Trouton's ratio is also enclosed in parentheses.

---

l_v = chaleur latente de vaporisation, joules par g à t, °C nécessaires pour produire la vapeur saturée à $t°$, le liquide étant sous sa propre tension de vapeur pendant l'évaporation.

Les valeurs marquées d'un astérisque (*) ont été obtenues en mesurant la chaleur de condensation. Toutes les autres valeurs ont été obtenues en mesurant l'apport d'énergie électrique, nécessaire pour évaporer un poids donné de liquide.

Les résultats obtenus par les méthodes de condensation (*) sont ordinairement trop faibles par le fait d'une condensation prématurée et sont aussi moins digne de confiance par le fait que la chaleur spécifique du liquide n'est généralement pas connue d'une façon précise. La plupart des résultats publiés avant 1900 peuvent être trop faibles de 10 joules et plus.

Pour les substances marquées d'une croix (†), la valeur donnée est extraite des tables détaillées de la section suivante, p. 138.

La température marquée entre parenthèses ( ) indique que la température n'a pas été mentionnée dans le mémoire original et que le point d'ébullition normal a été choisi. La valeur correspondante du rapport de Trouton est aussi mise entre parenthèses.

---

l_v = latente Wärme der Verdampfung, in Joule pro Gramm bei t, °C für die Erzeugung von gesättigten Dampf bei $t°$. Während der Verdampfung befindet sich die Flüssigkeit unter ihrem eigenen Dampfdruck.

Die mit einem Stern (*) bezeichneten Werte sind durch Messung der Kondensations-Wärme erhalten worden. Alle anderen Werte sind durch Messung der angewandten elektrischen Energie erhalten, die notwendig ist, eine gegebene Gewichtsmenge Flüssigkeit zu verdampfen.

Die nach der Kondensationsmethode (*) erhaltenen Werte sind gewöhnlich zu niedrig, einmal wegen der vorzeitigen Kondensation, dann aber auch deshalb, weil die spezifische Wärme der Flüssigkeit gewöhnlich nicht genau bekannt ist. Viele der Werte die vor dem Jahre 1900 publiziert worden sind, dürften deshalb um etwa 10 oder mehr Joule zu niedrig sein.

Für die mit einem Schwert (†) bezeichneten Stoffe ist der angegebene Wert einer besonderen Tabelle des folgenden Abschnittes, S. 138, entnommen.

Die in Klammer ( ) gesetzten Temperaturen bedeuten, dass diese nicht in der Originalmitteilung angegeben ist und der normale Siedepunkt genommen ist. Der entsprechende Trouton'sche Quotient ist ebenfalls in Klammer gesetzt.

---

l_v = calore latente di vaporizzazione, joules per g necessari a t, °C per produrre vapore saturo a $t°$, supponendo il liquido durante l'evaporazione sotto la sua tensione di vapore.

I valori segnati con un asterisco (*) sono stati ottenuti misurando il calore di condensazione. Tutti gli altri sono stati ricavati dal consumo di energia elettrica necessaria ad evaporare un dato peso di liquido.

I risultati ottenuti con il metodo di condensazione (*) sono per lo più troppo bassi a causa di una condensazione prematura e sono incerti anche perchè il calore specifico dei liquidi in genere, non è esattamente conosciuto. La massima parte dei risultati pubblicati prima del 1900, possono essere più bassi di 10 joules o anche più.

Per le sostanze segnate con (†) il valore dato è preso dalle tabelle riportate nella sezione seguente a p. 138.

Le temperature chiuse tra parentesi ( ) significano che non trovandosi indicata la temperatura nella memoria originale si è preso il punto di ebollizione normale. Il valore corrispondente del rapporto di Trouton è anche chiuso tra parentesi.

Trouton's ratio, $\frac{L_v}{T} = \frac{Ml_v}{273.1 + t}$

𝔅-Table

Formula	t, °C	l_v at t, °C, joule per gram	Trouton's ratio, L_v/T	Lit.
H_2O†	100	2258	109.0	*v.* p. 138
HF	17	1510	104	(33)*
HCl	− 84.3	413.1	79.8	(23)
	− 85.0	443.1	85.8	(28.5)
HBr	− 69.9	203.6	81.2	(23)
	− 66.72	217.7	85.3	(81)
HI	− 37.2	142.0	77.1	(23)
SO_2†	− 10.08	397	96.7	*v.* p. 138
SO_3	53	496	122.1	(29)*
H_2S	− 61.4	552.2	88.9	(23)
H_2SO_4	326	511	83.7	(65)*
S_2Cl_2	138	207	67.6	(62)*
	138	267	87.7	(33.5)
$SOCl_2$	82	228	76.4	(62)*
SO_2Cl_2	69.1	206.9	81.6	(74)*
$S_2O_5Cl_2$	140	256	133.3	(63)*
$ClSO_3H$	151	461	126.7	(63)*
NH_3†	− 33.4	1369	98.1	*v.* p. 138
HNO_3	86.0	481	84.4	(6)*
N_2O†				*v.* p. 138
N_2O_4	18	391	123.6	(14)*
NH_4Cl (solid)	350	330		(53)*
PCl_3	78	215	84.2	(1)*
$Si(OCH_3)_4$	121	194	75.0	(40)
$Si(OC_2H_5)_4$	156	141	42.5	(61)*
CO	(−192)	211.1	(73.0)	(24)
CO_2†				*v.* p. 138
$SiCl_4$	57	151	77.7	(40)
$SnCl_4$	112	127	85.9	(1)*
BCl_3	10	160	66.3	(8)*

𝔈-Table—𝔈-Arrangement (*v.* Vol. III, p. viii)

Formula	Name	t, °C	l_v at $t°$	Lv/T	Lit.
CClN	Cyanogen chloride	13	565	121.4	9)*
CCl_4†	Carbon tetrachloride	76.75	194.3	85.4	*v.* p. 138
CS_2†	Carbon disulfide	46.25	352	83.8	*v.* p. 138
$CHCl_3$†	Chloroform	61.5	247	87.9	*v.* p. 138
CHN	Hydrocyanic acid	20	880	81.1	(9)*
CH_2Cl_2	Methylene chloride	40.5	329	89.1	(57)
CH_2O_2	Formic acid	101	502	61.8	(15)
CH_3Cl	Methyl chloride	− 23.8	428	75.1	(72)
		+ 15.0	402		(79.5)
		20.0	399		(79.5)
		25.0	396		(79.5)
CH_3I	Methyl iodide	(42)	192	(86.5)	(54)
CH_3NO_2	Nitromethane	99.9	565	92.5	(57)
CH_4	Methane	−159	578	81.0	(67)
CH_4O†	Methyl alcohol	64.7	1100	104.3	*v.* p. 138
C_2Cl_4	Tetrachloroethylene	120.7	209.5	88.2	(57)
C_2N_2	Cyanogen	0	431	82.1	(19)*
C_2HCl_3	Trichloroethylene	85.7	239.6	87.8	(57)
C_2HCl_3O	Chloral		226		(7)*
$C_2H_2Cl_2O_2$	Dichloroacetic acid	194.4	323	89.1	(47)*
$C_2H_2Cl_4$	1, 1, 2, 2-Tetrachloroethane	145.0	230.5	92.6	(57)
C_2H_3ClO	Acetyl chloride	(51)	330	(79.9)	(11)*
$C_2H_3Cl_3O_2$	Chloral hydrate	96	552	274.4	(7)*
C_2H_3N	Acetonitrile	80	727	84.5	(38)*
$C_2H_4Br_2$	Ethylene bromide	130.8	193.5	90.0	(57)
$C_2H_4Cl_2$	Ethylene chloride	0.0	357		(36)*
		82.3	323.7	90.1	(57)
$C_2H_4Cl_2$	Ethylidene chloride	0.0	321		(36)*
		(60)	281	(83.5)	(13)*
C_2H_4O	Acetaldehyde	(21)	570	(85.3)	(4)*
C_2H_4O	Ethylene oxide	13	580	89.3	(10)*
$C_2H_4O_2$†	Acetic acid	118.3	405	62.1	*v.* p. 138
$C_2H_4O_2$	Methyl formate	31.3	470.3	92.8	(57)

C-TABLE.—(*Continued*)

Formula	Name	t, °C	l_v at t°	L_v/T	Lit.
C_2H_5Br	Ethyl bromide	38.4	250.8	87.8	(76)
C_2H_5Cl	Ethyl chloride	4.7	389	90.3	(37)
		15.0	387	86.6	(79.5)
		20.0	386		(79.5)
		25.0	385		(79.5)
C_2H_5ClO	2-Chloroethyl alcohol	126.5	514.6	103.7	(57)
C_2H_5I	Ethyl iodide	71.2	190.9	86.5	(57)
C_2H_6	Ethane	0	314		(19.5)
		− 10	341		(19.5)
		− 20	364		(19.5)
		− 30	386		(19.5)
		− 40	408		(19.5)
		− 90	10s0	177.3	(67)
C_2H_6O†	Ethyl alcohol	78.3	855	112.0	*v.* p. 138
$C_2H_6O_2$	Glycol	197	800	105.6	(48)*
C_2H_7N	Ethylamine	(15)	611	(95.5)	(28)*
C_3H_3N	Propionitrile	97	562	83.6	(47)*
C_3H_6O†	Acetone	56.1	521	91.9	*v.* p. 138
C_3H_6O	Allyl alcohol	(96)	684	(107.5)	(46)*
$C_3H_6O_2$	Ethyl formate	53.3	406.8	92.3	(57)
$C_3H_6O_2$	Methyl acetate	0.0	477		(36)*
		56.3	410.6	92.3	(57)
$C_3H_6O_2$	Propionic acid	139.3	413.6	74.3	(57)
$C_3H_6O_3$	Dimethyl carbonate	90	369	91.5	(46)*
C_3H_8	Propane	20	349		(19.5)
		+ 10	362		(19.5)
		0	375		(19.5)
		− 10	387		(19.5)
		− 20	399		(19.5)
		− 30	410		(19.5)
C_3H_8O†	*n*-Propyl alcohol	97.2	688	111.6	*v.* p. 138
C_3H_8O†	Isopropyl alcohol	82.3	667	118.4	*v.* p. 138
$C_3H_8O_2$	Methylal	42	376	90.8	(12)*
C_4H_4O	Furane	31	399	89.3	(57.2)
$C_4H_6O_3$	Acetic anhydride	137	277	68.9	(4)*
$C_4H_7ClO_2$	β-Chloroethyl acetate	141.5	338	99.9	(57)
C_4H_7N	*n*-Butyronitrile	117.4	481	85.1	(49)*
C_4H_8O	Methyl ethyl ketone	78.2	443.4	91.0	(57)
$C_4H_8O_2$	*n*-Butyric acid	163.5	477	96.2	(15)
$C_4H_8O_2$	Isobutyric acid	154	467	96.3	(15)
$C_4H_8O_2$	Ethyl acetate	0.0	427		(36)*
$C_4H_8O_2$	Methyl propionate	79.0	366.5	91.7	(57)
$C_4H_8O_2$	*n*-Propyl formate	80.0	368.9	92.0	(57)
C_4H_9I	*n*-Butyl iodide	129.5	192.1	87.8	(57)
C_4H_9NO	Methyl ethyl ketoxime	182	485	92.8	(49)*
C_4H_{10}	Butane	20	366		(19.5)
		10	376		(19.5)
		0	383	81.4	(19.5)
C_4H_{10}	Isobutane	20	333		(19.5)
		+ 10	345		(19.5)
		0	356		(19.5)
		− 10	366	80.8	(19.5)
$C_4H_{10}O$	*n*-Butyl alcohol	116.8	591.8	112.4	(57)
$C_4H_{10}O$	Isobutyl alcohol	106.9	578	112.7	(57)
$C_4H_{10}O$	*sec.*-Butyl alcohol	98.1	562.5	112.3	(57)
$C_4H_{10}O$	*tert.*-Butyl alcohol	83	546	113.6	(15)
$C_4H_{10}O$†	Ethyl ether	34.6	351	84.5	*v.* p. 138
$C_4H_{11}N$	Diethylamine	58	381	84.1	(59)*
$C_5H_4O_2$	Furfural	160.5	450	99.6	(57)
C_5H_5N	Pyridine	114.1	449.4	91.8	(57)
C_5H_9N	*n*-Valeronitrile	129	403	83.3	(39)*
C_5H_{10}	Amylene	12.5	314	77.1	(5)*
$C_5H_{10}O$	Diethyl ketone	101	380	87.5	(46)*
$C_5H_{10}O$	Methyl isopropyl ketone	92	376	88.7	(46)*
$C_5H_{10}O_2$	*n*-Butyl formate	105.1	363.1	98.0	(57)
$C_5H_{10}O_2$	Isobutyl formate	97.0	328.6	90.7	(57)
$C_5H_{10}O_2$	Ethyl propionate	97.6	335.2	92.3	(57)
$C_5H_{10}O_2$	Methyl *n*-butyrate	102.6	334	90.8	(15)
$C_5H_{10}O_2$	Methyl isobutyrate	91.1	327.0	91.7	(57)
$C_5H_{10}O_2$	*n*-Propyl acetate	100.4	336.0	91.9	(57)
$C_5H_{10}O_2$	*n*-Valeric acid	184.6	432	96.4	(15)
$C_5H_{10}O_2$	Isovaleric acid	176.3	423	96.1	(15)
$C_5H_{10}O_3$	Diethyl carbonate	126	306	90.6	(47)*
$C_5H_{11}Br$	*n*-Amyl bromide	129	202	(75.9)	(9)*
$C_5H_{11}I$	*n*-Amyl iodide	155	199	(92.1)	(9)*
$C_5H_{11}N$	Piperidine	106	374	84.0	(47)*
C_5H_{12}	Isopentane	13	371	93.5	(78)
$C_5H_{12}O$	*n*-Amyl alcohol	131	503	109.7	(68)*
$C_5H_{12}O$	Isoamyl alcohol	130.2	501.4	109.3	(57)

C-TABLE.—(*Continued*)

Formula	Name	t, °C	l_v at t°	L_v/T	Lit.
$C_5H_{12}O$	*tert.*-Amyl alcohol	102	443	104.1	(16)
$C_5H_{12}O$	Ethyl propyl ether	60.0	346	91.5	(60)
$C_5H_{13}N$	*n*-Amylamine	95	413	97.8	(38)*
C_6H_5Br	Bromobenzene	155.9	241.1	88.2	(57)
C_6H_5Cl	Chlorobenzene	130.6	324.8	90.5	(57)
$C_6H_5NO_2$	Nitrobenzene	210	331	84.3	(49)*
C_6H_6†	Benzene	80.2	394.8	87.2	*v.* p. 138
C_6H_7N	Aniline	183	434	88.6	(2.5)
C_6H_7N	α-Picoline	129	380	88.0	(39)*
C_6H_{10}	Cyclohexene	81.6	371.2	85.9	(57)
$C_6H_{10}O$	Mesityl oxide	128	359	87.8	(46)*
$C_6H_{10}O_4$	Diethyl oxalate	185	283	90.3	(48)*
$C_6H_{11}Cl$	Cyclohexyl chloride	142.0	313	89.4	(60)
$C_6H_{11}N$	Capronitrile	156	369	83.5	(47)*
C_6H_{12}	Cyclohexane	80.0	358.3	85.4	(57)
C_6H_{12}	Hexylene	0	388.3		(36)*
$C_6H_{12}O$	Cyclohexanol	161.1	453	104.5	(60)
$C_6H_{12}O$	Methyl *n*-butyl ketone	127	345	86.3	(46)*
$C_6H_{12}O_2$	*n*-Butyl acetate	124.0	309	90.4	(15)
$C_6H_{12}O_2$	Ethyl *n*-butyrate	118.9	312.6	92.6	(57)
$C_6H_{12}O_2$	Ethyl isobutyrate	109.2	301.6	91.6	(57)
$C_6H_{12}O_2$	Isoamyl formate	123	308	90.3	(15)
$C_6H_{12}O_2$	Isobutyl acetate	115.5	308.7	92.3	(57)
$C_6H_{12}O_2$	Methyl *n*-valerate	116	298	87.4	(69)*
$C_6H_{12}O_2$	Methyl isovalerate	116	303	90.4	(15)
$C_6H_{12}O_2$	*n*-Propyl propionate	120.6	306.2	90.3	(57)
C_6H_{14}	*n*-Hexane	0	373		(36)*
		66.9	342.1	86.7	(75)
		68	332	83.8	(52)*
$C_6H_{14}O$	Ethyl isobutyl ether	79.0	313	90.8	(60)
$C_6H_{14}O_2$	Acetal	102.9	277	87.0	(46)*
$C_6H_{15}N$	Di-*n*-propylamine	108	317	84.2	(39)*
C_7H_5N	Benzonitrile	189	367	81.9	(38)*
C_7H_6O	Benzaldehyde	179	362	84.9	(48)*
$C_7H_6O_2$	Salicylaldehyde	196	313	81.5	(50)*
C_7H_7Cl	*o*-Chlorotoluene	158.1	304	89.2	(57)
C_7H_7Cl	*p*-Chlorotoluene	160.4	306.1	89.4	(57)
C_7H_8	Toluene	109.6	362.2	87.2	(57)
C_7H_8O	Phenyl methyl ether	153	341	86.5	(49)*
C_7H_8O	Benzyl alcohol	204.3	470	106.4	(57)
C_7H_8O	*m*-Cresol	202	421	95.8	(47)*
C_7H_9N	Methylaniline	194	400	91.7	(49)*
C_7H_9N	*o*-Toluidine	198	398	90.5	(49)*
		198	382	86.8	(45)*
C_7H_{14}	Dimethylcyclopentane	91	339	91.4	(52)*
C_7H_{14}	Methylcyclohexane	99.9	321.9	84.7	(57)
$C_7H_{14}O$	Dipropylketone	143.5	317	86.9	(46)*
$C_7H_{14}O$	Methyl *n*-amyl ketone	149.2	346	93.6	(57.2)
$C_7H_{14}O_2$	*n*-Butyl propionate	144.9	300.3	82.0	(57)
$C_7H_{14}O_2$	Isobutyl propionate	137	276	76.8	(69)*
$C_7H_{14}O_2$	Ethyl *n*-valerate	98	328	99.3	(69)*
$C_7H_{14}O_2$	Ethyl isovalerate	144	284	77.7	(15)
$C_7H_{14}O_2$	Isoamyl acetate	143.6	289	79.2	(15)
$C_7H_{14}O_2$	*n*-Propyl *n*-butyrate	143.6	286	78.3	(15)
$C_7H_{14}O_2$	*n*-Propyl isobutyrate	134	267	74.9	(69)*
C_7H_{16}	*n*-Heptane	97.5	819.4	86.3	(57)
$C_7H_{16}O$	*n*-Heptyl alcohol	176	439	113.5	(15)
C_8H_8O	Acetophenone	203.7	323	81.4	(47)*
C_8H_{10}	Ethylbenzene	135.2	339.6	88.3	(57)
C_8H_{10}	*o*-Xylene	141.4	346.9	88.8	(57)
C_8H_{10}	*m*-Xylene	138.5	342.6	88.3	(57)
C_8H_{10}	*p*-Xylene	137.1	339.1	87.7	(57)
$C_8H_{11}N$	Dimethylaniline	193	338	87.8	(49)*
C_8H_{16}	Dimethylcyclohexane	118.5	300	85.9	(52)*
$C_8H_{16}O$	Methyl hexyl ketone	173	310	89.1	(48)*
$C_8H_{16}O_2$	Isoamyl propionate	161	273	90.7	(15)
$C_8H_{16}O_2$	Isobutyl *n*-butyrate	157	270	90.5	(15)
$C_8H_{16}O_2$	Isobutyl isobutyrate	148	265	90.7	(15)
$C_8H_{16}O_2$	*n*-Propyl isovalerate	156	270	90.7	(16)
C_8H_{18}	4-Methylheptane	117.2	296.5	86.7	(57)
C_8H_{18}	*n*-Octane	125	297	85.2	(52)*
$C_8H_{18}O$	*n*-Octyl alcohol	196	408	113.2	(15)
$C_8H\ O$	*dl-sec.*-Octyl alcohol	180	395	113.5	(15)
$C_8H_{19}N$	Diisobutylamine	134	275	87.3	(38)*
$C_9H_{10}O_2$	Ethyl benzoate	(213)	270	(83.5)	(44)*
C_9H_{12}	Mesitylene	165	311	85.3	(16)
C_9H_{12}	*n*-Propylbenzene	157	301	84.1	(69)*
C_9H_{12}	Pseudocumene	(169)	308	(83.8)	(45)*
$C_9H_{18}O_2$	Isoamyl *n*-butyrate	169	259	92.7	(15)

C-Table.—(*Continued*).

Formula	Name	t, °C	l_v at $t°$	L_v/T	Lit.
$C_9H_{18}O_2$	Isoamyl isobutyrate	168	241	86.5	(69)*
$C_9H_{18}O_2$	Isobutyl *n*-valerate	169	242	86.6	(69)*
$C_9H_{18}O_2$	Isobutyl isovalerate	169	253	90.5	(15)
$C_{10}H_8$	Naphthalene	218	316.0	82.4	(60)
$C_{10}H_{12}O$	*p*-Anethole	232	299	87.7	(51)*
$C_{10}H_{14}$	*p*-Cymene	176	283	84.5	(16)
$C_{10}H_{14}O$	Carvacrol	237	285	83.9	(51)*
$C_{10}H_{16}$	Limonene	165	291	90.4	(68)*
$C_{10}H_{16}$	Turpentine	156	287	91.1	(68)*
$C_{10}H_{20}O_2$	Ethyl caprylate	207	253	90.7	(15)
$C_{10}H_{20}O_2$	Isoamyl *n*-valerate	187	235	88.0	(69)*
$C_{10}H_{22}$	*n*-Decane	160	252	82.7	(46)*
$C_{10}H_{22}O$	*n*-Amyl ether	(170)	291	(104)	(26)*
$C_{11}H_{22}O_2$	Ethyl nonylate	227	243	90.5	(15)

SPECIAL TABLES

Arthur Whitmore Smith

l, joule/g; normal boiling points in bold-face type

H_2O (18, 21, 31, 34, 42, 56, 66, 73)

t, °C	l
0	2494
5	2482
10	2471
15	2459
20	2448
25	2436
30	2425
35	2413
40	2402
45	2390
50	2379
55	2368
60	2357
65	2345
70	2333
75	2321
80	2309
85	2297
90	2284
95	2271
100	2258
	±0.1%
105	2244
110	2230
115	2215
120	2200

Continued below

SO_2 (17, 22, 23, 57.5, 58, 71, 80)

−60	550(?)
−10.08	397
	±2%
−10	397
0	382
+10	367
20	352
30	338
40	323
50	309
60	294
157	0.0

N_2O (17, 55, 57.5, 58, 80)

t, °C	l
−30	284
−20	276
−10	263
0	246
+10	217
20	171
30	96
37	0.0

NH_3 (23, 30, 35, 64)

−45	1401
−40	1388
−35	1373
−33.4	1369
	±0.2%
−30	1359
−25	1344
−20	1329
−15	1313
−10	1296
− 5	1280
0	1262

Continued below

CO_2 (2, 3, 17, 43, 51.5, 57.5, 58, 80)

−78.5	577*
	±2%
−60	365
−50	349
−40	333
−30	312
−20	288
−10	263
0	234

* For the solid.

Continued below

C_6H_6 (15, 16, 32, 57, 58, 60, 69, 73.5, 79)

0	447.8
20	434.4
40	421.4

C_6H_6.—(*Cont'd*)

t, °C	l
60	408.0
80	394.2
80.2	394.8
	±0.1%
100	379.1
120	362.8
140	345.7
160	328.5
180	310.1
200	286.6
220	259.9
240	226.4
260	183.3
280	114.7
288.5	0.0

CH_4O (15, 16, 54, 57, 58, 75, 79, 80)

Methyl alcohol

t, °C	l
0	1190
20	1170
40	1140
60	1110
64.7	1100
	±2%
80	1060
100	1010
120	950
140	890
160	810
180	730
200	620
220	460
240	0.0

$C_2H_4O_2$ (15, 16, 25, 55, 58)

Acetic acid

20	365?
60	390?
100	400?
118.3	405
	±3%
140	395
180	370
220	340
321	0.0

C_2H_6O (15, 16, 46, 55, 57, 58, 75, 79, 80)

Ethyl alcohol

t, °C	l
0	920
20	910
40	900
60	880
78.3	855
	±4%
80	850
100	810
120	760
140	710
160	650
180	570
200	480
220	360
240	160
243	0.0

C_3H_6O (58, 77, 79, 80)

Acetone

0	564
20	552
40	536
56.1	521
	±2%
60	517
80	495
100	472
235	0.0

C_3H_8O (15, 16, 58, 70)

n-Propyl alcohol

0	810
80	721
97.2	688

C_3H_8O.—(*Cont'd*)

t, °C	l
	±1%
100	683
120	637
140	593
160	537
180	484
200	426
220	355
240	264
260	139
261	0.0

C_3H_8O (15, 16, 46, 57)

Isopropyl alcohol

82.3	667
	±2%
238	0.0

$C_4H_{10}O$ (15, 16, 41, 57, 58, 77)

Ethyl ether

0	387
20	366
34.6	351
	±2%
40	346
60	326
80	303
100	282
120	257
140	228
160	186
180	125
190	0.0

CCl_4 (54, 57, 58, 75, 79)

0	217.9
76.75	194.3

CCl_4.—(*Cont'd*)

t, °C	l
	±0.3%
80	193.3
100	185.5
120	176.8
140	167.7
160	159.4
180	148.7
200	137.0
220	123.7
240	107.4
260	84.3
280	43.8
283.1	0.0

$CHCl_3$ (54, 57, 58, 75, 79)

0	271
20	263
40	255
60	247
61.5	247
	±1%
80	239
100	231
260	0.0

CS_2 (57, 58, 79)

0	374
20	366
40	356
46.25	352
	±0.3%
60	344
80	331
100	316
120	300
140	282
273	0.0

H_2O, NH_3 AND CO_2 UP TO THE CRITICAL POINT

Oscar C. Bridgeman

H_2O (34)

t, °C	l
120	2199
125	2185
130	2170
135	2155
140	2139
145	2123
150	2107
155	2091
160	2074
165	2057
170	2039
175	2021
180	2003

NH_3 (23, 27.5, 34, 64, 65.7, 78.2)

−20	1239
−15	1313
−10	1297
− 5	1280

NH_3.—(*Cont'd*)

t, °C	l
0	1263
+ 5	1245
10	1226
15	1207
20	1187
25	1167
30	1146
35	1124
40	1101
45	1076
50	1051
132.5	0

CO_2* (19, 36.5, 57.7, 65.5)

−56.6	339
−55	337
−50	330
−45	323
−40	316

CO_2.*—(*Cont'd*)

t, °C	l
−35	308
−30	299
−25	290
−20	280
−15	269
−10	257
− 5	244
0	230
+ 5	214
10	195
15	174
20	147
25	112
30	50
31.1	0

* This table is based primarily upon the data of (37.5) while the table given above is in agreement with the data of (51.5) and the older literature.

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HEATS OF ADSORPTION AND OF WETTING

H. R. Kruyt and J. G. Modderman

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HEAT OF ADSORPTION

Abbreviations and Units

A Total amount of gas adsorbed per g of adsorbent, expressed in cm^3 reduced to NTP, unless otherwise indicated.

Q Total heat evolved by the adsorption of A, joules.

Gases on Charcoal

A, cm^3/g	Q, joule	P, range mm Hg	$\Delta Q/\Delta A$
Coconut C, heated to 550°, and out-gassed at 400° (d = 1.86) (14)			
	N_2, 0°C		
0.258	0.356	0–10.7	1.381
2.210	2.122	10.7–91.6	0.904
4.169	3.754	91.6–178.9	0.833
7.237	6.463	178.9–342.2	0.883
10.052	8.934	342.2–524.4	0.879
13.049	11.589	524.4–748.9	0.887
	NH_3, 0°C		
5.407	11.389	0–2.9	2.106
30.157	50.877	2.9–28.8	1.595
60.394	96.430	28.8–78.7	1.507
90.290	140.181	78.7–161.0	1.463
115.725	177.652	161.0–319.2	1.473
127.045	195.332	319.2–490.0	1.565
132.387	203.971	490.0–636.4	1.615
135.873	209.638	636.4–746.7	1.628

A, cm^3/g	Q, joule	P, range mm Hg	$\Delta Q/\Delta A$
Coconut C, heated to 550°, and out-gassed at 400° (d = 1.86) (14)			
	CO_2, 0°C		
2.286	3.300	0–2.2	1.443
11.310	15.542	2.2–18.7	1.357
22.556	29.916	18.7–55.1	1.278
33.416	43.539	55.1–122.1	1.254
43.904	56.436	122.1–229.3	1.230
50.850	64.921	229.3–337.7	1.222
56.937	(71.693)	337.7–471.3	(1.114)
61.639	77.345	471.3–605.5	1.199
65.112	81.467	605.5–730.9	1.187
Active coconut C, out-gassed at 350° (11)			
	CCl_4, 0°C		
23.56	70.6	0– << 4	2.99
39.50	111.4	<< 4– < 4	2.56
60.94	174.6	< 4–4	2.95
78.32	215.6	4–10	2.36
	CS_2, 0°C		
23.91	58.3	0– << 3	2.44
48.40	111.8	<< 3– << 3	2.18
70.02	157.5	<< 3– < 3	2.11
97.94	215.2	< 3–3	2.07
127.67	273.7	3–12	1.97
153.19	321.7	12–40	1.88

Gases on Charcoal.—(*Continued*)

A, cm³/g	Q, joule	P, range mm Hg	$\Delta Q/\Delta A$
Active coconut C, out-gassed at 350° (11)			
$CHCl_3$, 0°C			
22.30	62.4	0–<<7	2.80
45.49	123.1	<<7–<7	2.62
78.36	204.4	<7–7	2.47
107.10	274.2	7	2.43
CH_3OH, 0°C			
21.67	56.0	0–<<13	2.59
47.42	115.7	<<13–<<13	2.32
75.27	179.0	<<13–<13	2.27
103.27	240.4	<13–13	2.193
127.40	293.3	13–18	2.192
C_2H_5Cl, 0°C			
29.10	67.2	0–<<15	2.31
42.66	96.3	<<15–<<15	2.15
67.01	145.6	<<15–<15	2.02
102.81	214.3	<15–15	1.92
124.80	255.4	15–52	1.87
C_2H_5Br, 0°C			
48.90	124.9	0–<10	2.56
91.73	219.9	<10–10	2.22
120.48	281.0	10–37	2.13
C_2H_5I, 0°C			
34.42	90.9	0–<2	2.64
67.52	173.3	<2–2	2.49
99.17	251.0	2–5	2.46
124.72	310.2	5–39	2.32
C_2H_5OH, 0°C			
4.59	15.15	0	3.30
8.40	26.24		2.91
14.23	42.64		2.81
27.83	79.98		2.75
46.91	129.8		2.61
$HCO_2C_2H_5$, 0°C			
32.30	91.9	0–<<10	2.85
62.88	168.5	<<10–<10	2.50
96.73	249.8	<10–10	2.40
120.15	305.5	10–35	2.38
$(C_2H_5)_2O$, 0°C			
18.10	56.0	0–<<<10	3.10
37.68	109.1	<<<10–<<10	2.71
58.07	163.5	<<10–<10	2.67
86.77	225.1	<10–10	2.15
99.34	253.7	10–63	2.28
C_6H_6, 0°C			
28.37	80.2	0–<2	2.83
54.70	150.2	<2–2	2.649
81.03	219.9	2–3	2.647
102.04	273.3	3–13	2.54
Inactive coconut C, out-gassed at 350° (11)			
CCl_4, 0°C			
24.33	68.6	0–<21	2.82
36.27	94.4	<21–21	2.16
CH_3OH, 0°C			
32.65	83.5	0–<2	2.56
60.95	149.0	<2–2	2.32
88.35	211.0	2–4	2.26
117.09	274.7	4–14	2.22
C_6H_6, 0°C			
18.48	55.9	0–<4	3.02
36.28	106.5	<4–4	2.84
47.93	138.8	4–9	2.77

A, cm³/g	Q, joule	P, range mm Hg	$\Delta Q/\Delta A$
SO_2 on blood C (puriss. Merck) out-gassed at 450°C (d = 1.63); measurements at −10°C (16)			
21.4	41.9	0–1.0	1.956
54.2	97.3	1.0–3.6	1.691
87.4	151.3	3.6–9.2	1.626
123.5	205.2	9.2–16.4	1.492
159.2	256.7	16.4–(31.1)	1.445
193.8	304.0	(31.1)–45.0	1.366
226.5	353.4	45.0–(71.8)	1.510
256.8	398.3	(71.8)–(103.2)	1.483
283.2	437.2	(103.2)–136.4	1.472
323.4	493.9	136.4–(246.3)	1.411
352.1	533.3	(246.3)–397.3	1.371
369.7	556.4	397.3–533.0	1.315
386.4	575.2	533.0–(653.2)	1.125
409.9	600.4	(653.2)–720.5	1.073
439.9	631.6	720.5–755.0	1.039
466.3	659.5	755.0–764.0	1.059
C from the wood of *Evonymus europaeus*, out-gassed at red heat (3)			
Air, 0°C			
7.44	3.37	0–705	0.453
CH_3Cl, 0°C			
32.17	65.47	0–3.77	2.035
62.16	124.5	3.77–147.81	1.968
72.31	144.8	147.81–675.4	1.997
Active C de-ashed and out-gassed at 900°C (8)			
O_2, 0°C			
0.403	5.23		12.98
0.806	8.87		9.03
2.24	12.56		2.57
5.17	15.48		1.00
10.19	19.96		0.89
H_2O, 0°C*			
0.921	32.89		35.7
2.710	112.37		44.4
4.56	194.27		44.3
6.42	275.71		43.3
Cl_2, 0°C			
0.31	1.80		5.81
0.74	3.77		4.58
5.52	27.79		5.02
NH_3, 0°C			
3.70	9.37		2.53
14.92	26.11		1.51
24.75	40.93		1.51
34.45	55.03		1.45
CO_2, 0°C			
3.80	5.69		1.50
12.04	16.15		1.27
31.06	40.47		1.28
$(C_2H_5)_2O$, 0°C			
6.92	21.93		3.17
14.04	42.39		2.87
22.21	63.15		2.54
29.93	82.48		2.50
37.04	94.41		1.68
47.36	107.6		1.28
CCl_3NO_2, Chloropicrin, 0°C*			
0.307	20.84		67.9
0.672	42.48		59.3
1.012	59.89		51.2

* A in millimoles per gram.

A, cm³/g	Q, joule	P, range mm Hg	$\Delta Q/\Delta A$
Activated C dried at 150° and out-gassed at 100° (15)			
O_2, 0°C			
4.39	3.22	0–370	0.733
8.54	6.13	370–802	0.702
CO, 0°C			
4.84	4.01	0–233.1	0.83
9.40	7.60	233.1–540.1	0.79
CH_4, 0°; P corr. for N_2 (10%) present			
4.71	4.61	0–63.0	0.98
9.23	8.95	63.0–169.2	0.96
13.57	12.81	169.2–320.3	0.89
17.72	16.27	320.3–517.0	0.83

O_2 on "Norit" out-gassed at 900°C (2)

°C	A	Q	P, range	Q/A
15	0.216	2.59	0–	12.0
200†	0.302	6.43	0–2	21.3
310	0.158	5.07	0–2.7	32.1
450	0.133	5.55	0–3.4	41.7

† Above 200° CO_2 is formed and a correction has been applied for this heat of reaction.

Various gases on coconut C at −185°C; A is cm³ of gas adsorbed per cm³ (0.5–1 g) of charcoal from 0 to *ca.* 760 mm (4)

Gas	A	Q	Q/A
A	175	104.6	0.598
He	15	8.37	0.558
O_2	230	142.3	0.619
H_2	135	38.9	0.288
N_2	155	106.7	0.688
CO	190	115.1	0.606
$2H_2 + O_2$	150	71.1	0.474
$2CO + O_2$	195	144.4	0.740

Gases on various kinds of charcoal at room temperature and from 0 to *ca.* 760 mm; A and Q vary with the nature of the charcoal but the ratio is approx. constant (5)

Gas	HCl	HBr	HI	N_2O
Q/A	0.429	0.692	0.984	0.332

Gases on Metals

H_2 on Ni catalysts at 0° (7)

A, cm³	Q	$\Delta Q/\Delta A$
Catalyst I. Prepared by heating $NiCO_3$ at 300–320° for 120 hr and out-gassing at 300°; adsorbs 0.9 cm³ H_2 per g at *NTP*		
0.0396	0.1895	4.77
0.0772	0.3086	3.18
0.114	0.4184	2.93
0.180	0.5949	2.68
0.260	0.7936	2.49
0.795	2.0296	2.34
Catalyst II. Reduced for 60 hr; contained 13.5% ThO_2; adsorbs 0.72 cm³ H_2 per g at *NTP*		
0.0315	0.0804	2.56
0.0612	0.2325	5.11
0.0918	0.4187	6.08
0.1211	0.5832	5.57
0.2082	1.0143	4.95
0.2453	1.1646	4.01
0.332	1.3581	2.23
0.722	2.1933	2.14
CO_2 on Ni catalyst at 0° (7)		
Catalyst III. Reduced from the oxide for 260 hr at 300–320°; contained 4% Ce_2O_3		
0.082	0.271	3.29
0.619	1.04	1.43
0.874	1.24	0.789

H_2 on Ni and Cu at room temperature. The H_2 contained an unknown but negligible amount of N_2 (1)

A, cm³	Q	P, range	$\Delta Q/\Delta A$
On Ni reduced from NiO at 300°; results are greatly affected by previous treatment of the Ni			
0.403	0.998	0–2.7	2.48
0.865	2.086	2.7–8.7	2.35
1.123	2.792	8.7–703.4	2.73
On Cu reduced from CuO by H_2 at 145°			
0.438	0.786	0–760	1.793

Gases on Ni at 0° and from 0 to 760 mm (6)

H_2

Out-gassed at t, °C	A	Q	Q/A
304	5.2	15.70	3.03
240	3.7	10.98	2.97
196	2.9	8.56	2.95
145	2.1	5.49	2.61
120	1.8	4.28	2.38
90	1.5	3.22	2.15
0	0.54	1.16	2.15

Gas	A	Q	Q/A
C_2H_4	0.88	1.04	1.18
C_2H_6	0.75	0.78	1.05

H_2 and O_2 on Pt-black at 0° and from 0 to 760 mm (12); for H_2 on Pt-black carefully freed from O_2, A = 0.87 cm³ and $\Delta Q/\Delta A$ = 2.58; for O_2 the values of Q/A vary from 6 to 18 joule/cm³. The authors consider 6.6 as the best value.

Gases on SiO_2 and on Meerschaum

On meerschaum (d = 2.76) (3)

A	Q	P, range	$\Delta Q/\Delta A$
SO_2, 0°			
24.24	46.82	0–98.9	1.932
46.14	74.13	98.9–377.1	1.247
67.75	96.99	377.1–687.4	1.058
NH_3, 0°			
24.23	92.95	0–0	3.84
48.26	150.07	0–5	2.38
72.29	201.11	5–37.1	2.12
95.26	239.64	29.3–214.96	1.68
116.74	270.22	214.96–575.6	1.42
CH_3Cl, 0°			
20.96	41.07	0–34.9	1.959
39.59	66.78	34.9–484.9	1.380
41.72	69.67	484.9–561.9	1.355

On SiO_2 gel dried at 300° for 2 hr and out-gassed at 250°; contained 3.5–5.5% H_2O (13)

A	Q	P, range	$\Delta Q/\Delta A$
SO_2, 0°			
19.80	41.85	0–4.2	2.113
32.42	64.87	4.2–11.8	1.824
56.43	108.0	11.8–40.1	1.796
80.71	145.6	40.1–102.5	1.549
123.1	211.8	102.5–388.8	1.562
142.3	233.5	388.8–611.2	1.130
H_2O on the same gel, 0°; A in millimoles			
1.826	113.0	0–0.3	61.88
6.361	349.0	0.3–0.8	52.04
12.85	657.0	0.8–2.1	47.46
15.35	771.7	2.1–3.4	45.88
19.94	975.1	3.4–4.6	44.31

From Aqueous Solutions

Crystal violet on wetted blood charcoal (Merck) at room temp.; A in millimoles [9]

A	Q	$\Delta Q/\Delta A$
0.31	13.42	43.3
0.42	14.03	5.55

Salts on wetted blood charcoal (Merck) at room temp.; A in millimoles [10]

Salt	A	Q	Q/A
On Charcoal I. Heat of wetting = 25.11 J			
$LiNO_3$	0.214	5.36	25.0
$NaNO_3$	0.270	7.11	26.4
$CsNO_3$	0.354	12.05	34.1
On Charcoal II. Heat of wetting = 35.15 J			
$LiNO_3$	0.202	7.53	37.2
KNO_3	0.248	10.80	43.5
$CsNO_3$	0.336	16.49	49.0

LITERATURE

(For a key to the periodicals see end of volume)

[1] Beebe and Taylor, *1*, **46**: 43; 24. [2] Blench and Garner, *4*, **125**: 1288; 24. [3] Chappuis, *8*, **19**: 21; 83. [4] Dewar, *5*, **74**: 122; 04. *6*, **3**: 5; 04. [5] Favre, *6*, **1**: 209; 74. [6] Foresti, *36*, **53**: 487; 23. **54**: 132; 24. **55**: 185; 25. [7] Fryling, *50*, **30**: 818; 26. [8] Keyes and Marshall, *1*, **49**: 156; 27. [9] Kruyt and van der Spek, *55*, **24**: 145; 19.

[10] Lachs and Lachman, *7*, **123**: 303; 26. [11] Lamb and Coolidge, *1*, **42**: 1146; 20. [12] Mond, Ramsay and Shields, *7*, **25**: 657; 98. [13] Patrick and Greider, *50*, **29**: 1031; 25. [14] Titov, *7*, **74**: 641; 10. [15] Whitehouse, *54*, **45**: 13T; 26. [16] Williams, *68*, **37**: 161; 16.

HEAT OF WETTING

Except as otherwise indicated the values given represent heat of *complete* wetting, Q, in joules per g of the dry material.

Index.—The numbers are table numbers except those in ( ) which are literature references (*v.* p. 143).

Liquid	Fibers	Soils	Colloids	$PbSO_4$
H_2O	6 (12, 20, 28, 34)	(1, 6, 7, 8, 9, 10, 11, 15, 26, 30, 35)	10, 11	18

	Charcoal	SiO_2	Clays and earths	Starch, cellulose, etc.
H_2O	1, 2, 6, 12 to 16	1, 3, 4, 5, 6, 11, 12	1, 2, 11, 13	1, 6, 8, 9
CS_2, Carbon disulfide	1, 2, 15	1	1, 2	1
CCl_4, Carbon tetrachloride	1, 2	1, 3	1, 2	1
C_2Cl_4, Tetrachloroacetylene	15			
$CHCl_3$, Chloroform	1, 2	1, 7	1, 2	1
Hydrocarbons				
C_5H_{10}, Amylene			2	
C_5H_{12}, Pentane	1	1	1	1
C_6H_6, Benzene	1, 2, 15, 16	1, 3, 4	1, 2	1
C_6H_{10}, Cyclohexene			2	
C_6H_{12}, Hexamethylene	2		2	
C_6H_{14}, Hexane	1, 2	1	1, 2	1
C_7H_8, Toluene		4, 7		
$C_{10}H_{16}$, Pinene	2		2	
Alcohols				
CH_3OH, Methyl	1, 2, 15	1	1, 2	1
C_2H_5OH, Ethyl	1, 2, 15	1, 3	1, 2	1
C_3H_7OH, Propyl	1	1	1	1
$C_5H_{11}OH$, Amyl	1, 2	1, 7	1, 2	1
$C_6H_5CH_2OH$, Benzyl	1	1	1	1

Liquid	Charcoal	SiO_2	Clays	Starch
Ethers, esters, ketones, acids				
C_3H_6O, Acetone	1, 2	1	1, 2	1
$C_4H_8O_2$, Ethyl acetate	2		2	
$C_4H_{10}O$, Ether	1, 15	1, 7	1, 2	1
Fatty acids	1	1	1	1
Naphthenic acids			2	
N compounds				
C_5H_5N, Pyridine		4, 7		
$C_6H_5NH_2$, Aniline		3	2	
$C_6H_5NO_2$, Nitrobenzene		4		
Miscellaneous				Cu
Petroleum products	2		2	17
Vegetable oils				17

TABLE 1.—POWDERS DRIED AT 100°

Experiments at 12–13° [14]

Liquid	Clay	Amorph. silica	Starch	Sugar charcoal
H_2O	52.7	64.0	85.4	16.3
CH_3OH	46.0	64.0	23.4	48.1
C_2H_5OH	45.2	61.5	20.5	28.9
C_3H_7OH	42.7	56.5	29.3	23.4
$C_5H_{11}OH$	42.3	56.5	13.0	15.5
$C_6H_5CH_2OH$	38.9	56.5	17.6	15.5
$HCOOH$	50.2	60.7	33.5–41.8	50.2±
CH_3COOH	38.9	56.5	12.6–16.7	25.1
C_2H_7COOH	32.6	56.5	12.6–16.7	25.1
CH_3COCH_3	33.5	56.5	8.4	15.1
$CHCl_3$	37.7	33.5	8.4	9.6
$C_2H_5OC_2H_5$	24.3	35.2	9.2	5.0
C_6H_6	24.3	33.9	5.0	17.6
CCl_4	7.5	33.9	7.1	6.3
CS_2	7.1	15.1	2.1	16.7
C_5H_{12}–C_6H_{14}	5.0	13.0	1.26	1.67

TABLE 2 [17]

Liquid	Clay	"Floridin"	Bone charcoal
Amylene	329.8	239.0	
H_2O		126.0	77.4
Cyclohexene		117.6	
CH_3COCH_3		114.2	80.8
Pinene	86.2		72.0
CH_3OH	115.5	91.2	73.7
$CH_3CO_2C_2H_5$		77.4	69.1
C_2H_5OH	102.5	72.0	69.1
$C_6H_5NH_2$		56.1	
$C_5H_{11}OH$	85.4	45.6	44.4
$C_2H_5OC_2H_5$		43.9	
$CHCl_3$	65.7	35.2	58.6
C_6H_6	45.2	23.4	46.5
CCl_4	41.4	19.3	35.2
CS_2	39.3	17.6	58.2
Hexamethylene		17.6	38.5
C_6H_{14}	30.1	16.3	37.2
Petroleum fractions* B. P., 220–225°		22.2	56.1
Petroleum fractions* B. P., 150–155°		18.8	49.4
Gasoline, B. P., 80–85°		17.6	39.8
Naphthenic acids† Mol. wt., 405		59.4	
Naphthenic acids† Mol. wt., 298		56.5	
Naphthenic acids† Mol. wt., 221		53.6	

* Treated with fuming H_2SO_4 to remove unsaturated and aromatic hydrocarbons. † Diluted with 20 vol. % of gasoline to decrease viscosity.

TABLE 3 (31)

Liquid	SiO_2 gel
H_2O	80.4
C_2H_5OH	94.7
C_6H_6	46.6
CCl_4	35.2
$C_6H_5NH_2$	73.4

TABLE 4.—SiO_2 OUT-GASSED AT RED HEAT (25)

Liquid	Mean diam., cm 5×10^{-4}	Mean diam., cm 9.6×10^{-4}
H_2O	57.8	28.9
$C_6H_5NO_2$	46.2	26.2
$C_6H_5CH_3$	35.6	20.3
C_6H_6	17.1	17.1
C_5H_5N	50.8	20.8

TABLE 5.—SiO_2 WITH H_2O (29)

Specimen SiO_2	Q at 7°	Diam., cm $\times 10^{-4}$	Joule/m^2
SiO_2 (glass wool)	3.85	17.5	46.0
SiO_2 (fine gray sand)	0.96	100.	41.8
SiO_2 I (precipitated)	47.3	2.5	43.5
SiO_2 II (precipitated)	30.1	4.0	43.9
SiO_2 II (precipitated)	31.6 (Q at 24°)		

Heat of Complete Wetting per g Dry Material (Q_i)

Powders containing varying initial amounts of hygroscopic moisture, i = mg H_2O per g dry powder.

TABLE 6.—WITH H_2O

Powder	i	Q_i	i	Q_i
Cellulose (22, 23); dried *in vacuo* at 116°	14	33.90	74	10.89
	41	19.67	261	4.61
	54	16.74		
Animal charcoal at 0° (22, 23)	0	87.51	563	13.06
	49	73.91	659	6.66
	90	64.20	718	4.56
	218	49.34	753	1.21
	350	33.07	930	0
	437	25.32		
SiO_2 gel at 0° (4)	23	77.59	275	22.57
	57	50.93	399	15.48
	87	38.50	565	6.95
	129	32.14	769	0.80
	188	27.20		
Wood fiber (12)	?	67		

TABLE 7.—SiO_2 GEL WITH VARIOUS LIQUIDS (4)

Liquids	i	Q_i	Liquids	i	Q_i
$C_6H_5CH_3$	23	32.73	$C_5H_{11}OH$	17	51.35
$CHCl_3$	13	32.52	$C_2H_5OC_2H_5$	31	68.59
C_5H_5N	18	60.05	$C_2H_5OC_2H_5$	276	37.04
$C_5H_{11}OH$	27	55.87			

TABLE 8.—STARCH WITH H_2O AT 0° (HEAT OF SWELLING)

The starch has been dried for 21 days in partial vacuum above H_2SO_4, Q = 110.5 joule/g (32).

TABLE 9.—DEXTRIN WITH H_2O

Q = 67.6 joule/g (33).

TABLE 10.—HEAT OF SWELLING AND OF SOLUTION, PER G MATERIAL (36)

Material	Amount	$+H_2O$	Q
Gelatin			
t = 42.5°	1 g	5 g	+13.0
t = 42.5°	1 g + 100% H_2O	4 g	− 4.18
t = 34.3°	1 g + 200% H_2O	3 g	− 4.18
t = 25°	1 g + 300% H_2O	2 g	0
Gum arabic	1 g	5 g	+37.6
	1 g + 50% H_2O	2 g	− 2.5
Gum tragacanth	1 g	5 g	+43.1

TABLE 11.—COLLOIDS WITH H_2O (9)

Colloid	Q	Colloid	Q
$Al(OH)_3$	89.6	Silica gel	101.5
$Fe(OH)_3$	39.3	Fuller's earth	88.9
Quartz	1.88		

TABLE 12.—SILICA AND ANIMAL CHARCOAL, WITH WATER (13)

	Q
Silica (dried at 200°)	55.41
Charcoal (puriss.)	59.55

TABLE 13.—WITH H_2O (18, 19)

Coconut charcoal (out-gassed)	43.9	Bone charcoal	77.4
Coconut charcoal (containing 0.04 g H_2O)	14.6	Fuller's earth	134

TABLE 14.—WITH H_2O

Graphite preheated *in vacuo*. Q = 2.85 joule/g (27).

TABLE 15.—"BAYER" CHARCOAL AT ROOM TEMPERATURE (2)

Liquid	Q	Liquid	Q
$C_2H_5OC_2H_5$	118.4	CH_3OH	126.4
C_6H_6	123.0	C_2Cl_4	137.3
CS_2	125.6	H_2O	51.5*
C_2H_5OH	118.9		

* With 0.66 cm^3 H_2O per g. Possibly incomplete wetting.

TABLE 16.—VARIOUS CHARCOALS WITH H_2O AND C_6H_6

The activity, a, is taken as proportional to the adsorptive power for H_2 (21). d is approximate.

a	d	H_2O	C_6H_6	a	d	H_2O	C_6H_6
10		20.9	25.1	75	1.87	154.8	209.0
20		41.8	54.4	90		188.3	251.1
25	1.45	50.2	71.1	98	2.00	205.1	272.0
50		104.6	138.1	100		209.0	280.4

TABLE 17.—Cu WITH OILS

All samples (except kerosene) diluted 1:2 with C_6H_6; Q for C_6H_6 taken as 0 (3)

Oil	Q	Oil	Q
Castor oil	0.51	Paraffin oil	0.16
Linseed oil	0.58	Kerosene	0.24
Lubricating oil, distillate	0.60	Kerosene + 1% oleic	
Lubricating oil, refined	0.26	acid	0.89

For temperature rise on wetting charcoal with oils, *v.* (3.5).

TABLE 18.—$PbSO_4$ WITH ITS SATURATED AQUEOUS SOLUTION

For total surface of 5840 to 32 400 cm^2/g, Q = 0 (24).

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THERMAL EFFECTS ACCOMPANYING PRESSURE CHANGES IN HOMOGENEOUS SYSTEMS (JOULE-THOMSON AND RELATED EFFECTS)

J. R. ROEBUCK

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JOULE-THOMSON EFFECT $\mu = \left(\frac{\partial T}{\partial P}\right)_h$, $h = U + pv$

A-TABLE, ELEMENTARY SUBSTANCES AND ATMOSPHERIC AIR

Values of μ in °C/atm. (11)

°C	0	20	40	60	80	100
H_2	−0.013	0.018	0.023	0.028	0.033	−0.039
He	*v.* (17)					
N_2	+0.333	0.291	0.250	0.215	0.187	+0.159
O_2	+0.366	0.328	0.289	0.255	0.224	+0.193

Air, values of 10^3a and 10^5b in the equation, $\mu = a - bp$, for p in kg/cm², and μ in °C/kg cm^{-2} (14)

°C	−55	−34	−0.6	+49.2	99.5	149.7	199.3	249.9
10^3a	448	375	272	197	138	84	52	18
10^5b	176	129	81	56	36	18	13	10

Air, values of $10^3\mu$, unit, °C/atm. (20); *cf.* (9)

p, atm.	0°	50°	100°	150°	200°	250°	280°C
1	266	189	133	93	62.5	40.2	29.7
20	249	178	124	86	56.4	34.6	24.6
60	214	153	106	71	44.7	25.1	16.1
100	178	128	89	59	34.7	16.4	7.8
140	145	105	72	46.7	25.8	9.3	+ 1.1
180	113	83	58	36.6	18.5	+2.7	− 5.4
220	81	63	45	28.6	12.7	−2.0	−11.0

Air, values of $10^3\mu$, unit, °C/atm. (25)

p, atm. \ °C	−25	−50	−75	−100	−110	−120	−130	−140	−150	p, atm. \ °C	−25	−50	−75	−100	−110	−120	−130	−140	−150
1	317	378	462	576	637	710	807	936	1100	120	187	214	242	203	158	102	57	28	+11
20	297	358	442	562	627	710	819	967	1200	140	164	172	192	142	108	69	38	17	0
40	276	336	417	534	598	577	776	245	52	160	143	155	147	103	76	47	+22	+ 3	−12
60	255	309	378	472	541	527	362	106	40	180	125	130	116	75	52	28	8	− 8	−22
80	232	275	335	386	367	299	141	67	34	200	108	110	82	48	29	+13	− 3	−17	−29
100	211	248	288	284	242	158	87	43	21	220	93	91	69	31	+14	− 2	−15	−28	−42

Air, values of μ in °K/atm. (8)

p, atm.	p, kg/cm²	90°	120°	132.6°*	150°	180°	210°	240°	270°	300°K
0	0	2.045	1.265	1.046	0.833	0.602	0.459	0.361	0.285	0.227
25	25.84	−0.005	0.059	1.065	0.847	0.619	0.458	0.345	0.266	0.212
37.17†	38.40	−0.010	0.028	0.723	0.787	0.599	0.443	0.332	0.254	0.204
50	51.67	−0.014	0.013	0.136	0.641	0.555	0.420	0.315	0.244	0.195
75	77.50	−0.020	0.000	0.036	0.266	0.436	0.362	0.282	0.221	0.178
100	103.33	−0.026	−0.010	0.010	0.130	0.299	0.295	0.247	0.196	0.159
125	129.18	−0.031	−0.020	−0.005	0.062	0.203	0.233	0.211	0.172	0.142
150	155.00	−0.035	−0.026		0.025	0.135	0.182	0.175	0.148	0.124
175	180.83	−0.038	−0.032		0.000	0.079	0.130	0.139	0.124	0.106
200	206.7	−0.041	−0.036		−0.017	0.029	0.080	0.101	0.099	0.089

* Critical temperature. † Critical pressure.

B-TABLE, CHEMICAL COMPOUNDS

CO_2, unit, °C/atm. (2)

Temp., °K	Pressure in atmospheres								
	0	1	10	20	40	60	72.9	80	100
	Vapor phase above line								
400.0	0.6475	0.6440	0.6210	0.5950	0.5375	0.4790	0.4410	0.4225	0.3635
390.0	0.6755	0.6725	0.6485	0.6200	0.5595	0.4965	0.4560	0.3850	0.3235
380.0	0.7080	0.7045	0.6780	0.6475	0.5835	0.5165	0.4742	0.4505	0.3855
370.0	0.7415	0.7335	0.7100	0.6775	0.6160	0.5405	0.4952	0.4705	0.3995
360.0	0.7790	0.7750	0.7455	0.7110	0.6420	0.5685	0.5200	0.4930	0.4155
350.0	0.8195	0.8150	0.7850	0.7500	0.6780	0.6020	0.5500	0.5210	0.4340

CO_2.—(*Continued*)

Temp., °K	Pressure in atmospheres								
	0	1	10	20	40	60	72.9	80	100
340.0	0.8640	0.8595	0.8290	0.7950	0.7205	0.5425	0.5872	0.5550	0.4500
330.0	0.9140	0.9095	0.8795	0.8450	0.7720	0.6925	0.6331	0.5945	0.4490
325.0	0.9425	0.9375	0.9075	0.8745	0.8025	0.7230	0.6605	0.6165	0.4220
320.0	0.9710	0.9665	0.9380	0.9050	0.8360	0.7570	0.6900	0.6380	0.3570
315.0	1.0020	0.9985	0.9705	0.9395	0.8735	0.7970	0.7223	0.6500	0.2210
310.0	1.0360	1.0320	1.0055	0.9765	0.9160	0.8435	0.7554	0.6100	0.1585
305.0	1.0710	1.0675	1.0445	1.0155	0.9640	0.9000	0.7468	0.2690	0.1270
304.1	1.0775	1.0740	1.0505	1.0240	0.9735	0.9100	0.6050	0.2420	0.1215
300.0	1.1070	1.1045	1.0840	1.0600	1.0175	0.9675	0.2147	0.1650	0.1005
295.0	1.1480	1.1455	1.1270	1.1090	1.0805	0.1990	0.1324	0.1134	0.0794
290.0	1.1920	1.1900	1.1750	1.1635	1.1525	0.1156	0.9999	0.0815	0.0619
285.0	1.2395	1.2385	1.2280	1.2245	1.2400	0.0761	0.06355	0.0586	0.0478
280.0	1.2900	1.2900	1.2845	1.2915	1.3470	0.0515	0.0454	0.0425	0.0364
275.0	1.3455	1.3455	1.3470	1.3645	0.0414	0.0355	0.0324	0.0309	0.0275
270.0	1.4050	1.4060	1.4155	1.4455	0.0274	0.0246	0.0228	0.0221	0.0202
260.0	1.5375	1.5405	1.5735	1.6375	0.0106	0.0101	0.00973	0.0096	0.0090
250.0	1.6885	1.6954	1.7570	0.0_3735	0.0_3733	0.0_3731	0.0_3730	0.0_3729	0.0_3727
240.0	1.860	1.870	1.974	−0.00723	−0.00742	−0.00761	−0.00774	−0.00781	−0.00801
230.0	2.060	2.070	−0.0168	−0.0171	−0.0177	−0.0183	−0.0187	−0.0190	−0.0195
220.0	2.2855	2.3035	−0.0294	−0.0304	−0.0323	−0.0341	−0.0353	−0.0359	−0.0375

Liquid phase below line

Supplementary values at graphically determined intersections of isotherms and isobars of μ with the saturation curve

p	1	5	10	15	20	30	40	50	60	65	70	72.9
T	(193.5)	216.2	233.4	245.05	254.1	268.15	279.0	288.0	295.7	299.15	302.35	304.1
μ_v	(3.055)	2.510	2.135	1.922	1.773	1.545	1.371	1.211	1.043	0.937	0.801	0.6050
μ_l	(?)	−0.0346	−0.0083	−0.0031	+0.0046	0.0245	0.0575	0.1182	0.2225	0.2985	0.418	0.6050
T	216.9	220.0	230.0	240.0	250.0	260.0	270.0	280.0	285.0	290.0	295.0	300.0
p	5.15	5.95	8.8	12.65	17.6	23.9	31.55	41.0	41.0	52.55	59.0	61.3
μ_v	2.475	2.410	2.200	2.020	1.841	1.675	1.515	1.354	1.354	1.174	0.961	0.914
μ_l	−0.3375	−0.0290	−0.0167	−0.0074	+0.0007	0.0115	0.0285	0.0625	0.0938	0.1386	0.2095	0.3235

Values below correspond to regions of rapid rates of change of μ along isotherms

T	220.0	230.0	304.1	304.1	304.1	304.1	304.1	310.0	310.0	315.0	315.0	315.0
p	5.0	5.0	70.0	72.0	74.0	76.0	90.0	85.0	90.0	85.0	90.0	95.0
μ	2.387	2.132	0.822	0.767	0.382	0.310	0.159	0.360	0.250	0.569	0.443	0.312

μ as a function of p along isenthalpic (or total heat) curves

Pressures in atmospheres; temperatures in °K; μ in °K per atm.

p	0	1	20	40	60	72.9	80	100
				Vapor isenthalps				
T	379.94	380.63	393.12	404.56	414.39	420.00	422.88	430.22
μ	0.7080	0.7029	0.6118	0.5284	0.4564	0.4154	0.3944	0.3407
T	356.30	357.10	370.92	383.40	394.00	400.00	403.05	410.74
μ	0.7924	0.7860	0.6748	0.5745	0.4892	0.4410	0.4165	0.3546
T	331.40	332.30	347.99	361.90	373.52	380.00	383.27	391.43
μ	0.9054	0.8974	0.6582	0.6348	0.5317	0.4742	0.4452	0.3728
T	304.30	305.35	323.77	339.76	352.85	360.00	363.57	372.35
μ	1.0760	1.0655	0.8816	0.7220	0.5914	0.5200	0.4844	0.3967
T	272.42	273.88	297.03	316.46	331.83	340.00	344.00	353.64
μ	1.3750	1.3590	1.0885	0.8620	0.6826	0.5872	0.5405	0.4280
T	226.91	229.09	263.56	290.42	310.15	320.00	324.63	335.27
μ	2.1272	2.0948	1.5620	1.1470	0.8422	0.6900	0.6184	0.4540
T	208.69	211.26	[252.26]	282.91	304.56	315.00	319.82	330.59
μ	2.5786	2.5338	[1.8181]	1.2826	0.9046	0.7223	0.6381	0.4501

CO_2.—(*Continued*)

p	0	1	20	40	60	72.9	80	100
T	181.28	[184.70	237.43	274.42]	298.85	310.00	314.97	325.60
μ	3.4295	[3.3588	2.2620	1.4928]	0.9850	0.7533	0.6500	0.4290
T	157.40	[161.24	226.49	269.35	295.97]	307.50	312.48	322.77
μ	4.343	[4.2514	2.6950	1.6727	1.0380]	0.7630	0.6442	0.3998
T	120.90	[126.80	212.44	264.32	293.71]	305.50	310.36	319.77
μ	6.000	[5.832	3.400	1.926	1.091]	0.7560	0.6179	0.3508
T	76.00	[81.40	198.40	260.85	292.77]	304.50	309.09	317.42
μ	8.396	[8.114	4.288	2.1915	1.1200]	0.7264	0.5724	0.2926
Critical isenthalp								
T	0.00	[13.38	182.77	260.56	293.70	304.10]	307.80	313.82
μ	13.580	[13.01	5.783	2.463	1.049	0.6050]	0.4470	0.1906
Liquid isenthalps								
T	[195.21	198.25	251.57	281.51	297.44]	303.50	305.92	310.43
μ	[3.7974	3.6800	2.0194	1.0744	0.5716]	0.3804	0.3041	0.1618
T	[245.42	247.07	271.83	287.94	297.79]	302.00	303.81	307.48
μ	[1.6720	1.6312	1.0210	0.6239	0.3812]	0.2774	0.2329	0.1423
T	[265.03	265.92	280.04	290.11	296.87]	300.00	301.41	304.45
μ	[0.9102	0.8924	0.6108	0.4099	0.2751]	0.2127	0.1846	0.1239
T	[275.86	275.93	277.16]	278.34	279.39	280.00	280.32	281.14
μ	[0.06978	0.06936	0.06202]	0.05514	0.04901	0.04543	0.04357	0.03873
T	[259.24	259.26	259.46]	259.67	259.88	260.00	260.07	260.26
μ	[0.01096	0.01094	0.01064]	0.01027	0.00993	0.00973	0.00962	0.00931
T	[240.54	240.53]	240.40	240.29	240.10	240.00	239.94	239.79
μ	[−0.00704	−0.00705]	−0.00723	−0.00742	−0.00761	−0.00773	−0.00781	−0.00801
T	[222.19	222.17]	221.66	221.08	220.44	220.00	219.74	218.98
μ	[−0.02537	−0.02548]	−0.02778	−0.03040	−0.03329	−0.03528	−0.03464	−0.03989

H_2O Vapor, unit, °C/kg cm^{-2} (5)

°C	120	150	200	250	300	350	400
μ	5.33	3.63	2.20	1.50	1.15	0.90	0.75

At 165°C and 3.86 kg/cm², μ = 3.182 (24).

CH_4, values of $\mu = \frac{t_1 - t_2}{p - 1}$ °C/atm. ±*ca.* 0.05 (21); *cf.* (15)

p	25	17	14.6	27	55
t_1, °C	−77	−78	−78	+10	10
μ	0.75	0.75	0.74	0.35	0.40

C_2H_5Cl, values of μ in °C/atm. for pressures less than 3 atm. (10)

°C	0	20	40	60	80	100
μ	5.22	4.51	3.86	3.31	2.84	2.43

Inversion Temperatures

$\mu = 0$ at t, °C and at $p_{atm.}$

t	p	Gas	t	p	Lit.
Air (20)		He	−173	(1)	(17)
300.4	90.1	H_2	80.5*	113	(15)
283.0	137.0	Liq. air	−133	150	(8, 12)
252.8	176.7	Liq. air	−140	125	(8, 12)
240.1	199.1	CO_2 (liq.)	− 24.0	18 to 100	(2)

* Temperature at which a drop from p to 1 atm. gives zero integrated cooling effect.

CHANGE IN TEMPERATURE ON ADIABATIC EXPANSION

H_2O, values of $10^5\left(\frac{\partial t}{\partial p}\right)$, unit, °C/kg cm^{-2}

p, kg/cm²	Lit. (18)	(1)	(1)	(18)	(18)	(1)	(18)	(1)	(1)	(18)
	0°		20°	25°	37°	40°	54°	60°	80°	
1	−130	−16	+137	+ 66	260	287	390	417	548	492
500	− 20	+68	175	130	273	300	371	417	500	468
1 000	+ 64	132	220	167	279	309	357	413	462	445
1 500	116	183	248	188	279	316	344	406	427	423
2 000	150	215	263	203	279	322	335	397	403	406
3 000	189	251	280	223	284	325	325	381	367	382
4 000		260	283	240		323		366	344	
6 000		194	289			336		349	308	
8 000			355			333		337	279	
10 000						330		330	257	
12 000						320		320	238	

For calculated values 0 − 30°C and 1 to 1000 atm., *v.* (23).

Miscellaneous Substances

Substance	p	1	500	1000	1500	2000	2500	3000
	°C	$10^5\frac{(dt)}{(dp)}$ (19)						
Benzene	90	2550	2000	1620	1390	1210	1090	990
Urethane	80	1300	1072	884	765	702	639	

Miscellaneous Substances.—(*Continued*)

Substance	p	1	500	1000	1500	2000	2500	3000
	°C	$10^5 \frac{(dt)}{(dp)}$ (19)						
Mix. A*	90	2400	1890	1560	1300	1110	990	880
Phenol	80	1130	999	883	802	726	648	
p-Toluidine	80	1300	1158	1034				
Mix. B*	80	1160	1016	905	782	691	644	
Ethyl alcohol	30	1450	1180	965	805	715	658	
Water	0	−130	−20	+64	+116	+150	+173	+189
	80	492	468	445	423	406	392	382
Glycerol	25	437	407	380	352	327	308	294
	98.2	625	570	520	475	441		
Castor oil	0	785	700	628	564	507	468	448

* Mix. A is 75 mol % Benzene + 25 mol % Urethane. Mix. B is 75 mol % Phenol + 25 mol % *p*-Toluidine.

AQUEOUS SOLUTIONS (22)

Changes of temperature on adiabatic expansion

Wt. % KCl	0.747		7.11		19.43		Wt. % NaCl	5.63		10.68	
ΔP	Δt		Δt		Δt		ΔP	Δt		Δt	
101	−0.07		−0.05		−0.21		101	−0.10		−0.21	
200	−0.05		−0.16		−0.39		200	−0.15		−0.34	
300	−0.11		−0.26		−0.60		300	−0.24		−0.49	
400	−0.12		−0.44		−0.72		400	−0.42		−0.67	
498	−0.15		−0.55		−0.96		498	−0.55		−0.79	
Wt. % H_2SO_4	3.94		7.69		Wt. % $ZnSO_4$	2.85		5.55		8.11	
ΔP	Δt		Δt		ΔP	Δt		Δt		Δt	
101	−0.11		−0.12		101	−0.02		−0.05		−0.09	
200	−0.12		−0.32		200	−0.04		−0.10		−0.16	
300	−0.25		−0.38		300	−0.10		−0.17		−0.24	
400	−0.38		−0.58		400	−0.18		−0.24		−0.32	
498	−0.54		−0.79		498	−0.27		−0.36		−0.45	

Wt. % C_2H_5OH	4.99	10.18
Wt. % NaCl	0.60	0.62
ΔP	Δt	Δt
101	−0.006	−0.04
200	−0.01	−0.09
300	−0.01	−0.13
400	−0.04	−0.19
498	−0.10	−0.24

Liquid NH_3, values of $l = \left(\frac{\partial Q}{\partial p}\right)_T$ (16)

Unit, joules per kg/atm.

°C	−44.1	−39.0	−24.2	−0.2	16.5	26.5	35.4	40.3
l	−57	−59	−70	−91	−111	−127	−145	−155

HEAT OF ISOTHERMAL COMPRESSION

$$Q = \int_0^p f(p)dQ$$

H_2O, values of $10^5 Q$, unit g-cal/g (1)

p, kg/cm²	0°	20°	40°	60°	80°C
0	0.0	0.0	0.0	0.0	0.0
500	0.2	0.7	1.5	2.1	2.6
1 000	0.6	1.6	2.9	4.1	5.0
2 000	1.9	3.8	5.8	7.9	9.2
3 000	4.0	6.4	8.7	11.4	13.1
4 000	6.4	8.9	11.6	14.6	16.5
6 000	10.6	14.0	17.3	20.9	23.2
8 000		19.6	23.1	27.0	29.3
10 000			28.7	32.9	35.3
12 000			34.5	38.8	40.8

Calculated values for CS_2, ether, alcohol and H_2O (3). Calculated values at 0°C for ethylene chloride, ethyl chloride, ethyl bromide, ethyl iodide, methyl acetate, ethyl acetate, benzene, toluene, xylene, cymene, bromine, mercury, acetone, carbon disulfide, carbon tetrachloride, chloroform and ether (13).

HEAT OF ELASTIC EXTENSION OF METALS

$\frac{\Delta t}{\Delta \tau} = -\frac{aT}{cd}$, where $\Delta \tau$ = tension increase and Δt the corresponding temperature increase, a = the coefficient of thermal expansion, d the density, c the specific heat per gram and T the temperature in °K; Q = heat absorbed.

$\Delta \tau$, kg/cm²	Δt, °C	Q, g-cal$_{15}$/cm³	
Steel at 23.9°C, d = 7.93 g/cm³ (4)			
1656	−0.1369	0.1279	±0.4%
3312	−0.2737	0.2556	
4968	−0.4106	0.3836	
German silver at 16.4°C, d = 8.40 g/cm³ (7)			
969	−0.1405	0.1135 ±3%	

TEMPERATURE CHANGE IN PLASTIC EXTENSION (6)

$100\ \Delta l/l_0$ = % elongation.

Δt_t = Temp. rise with tension maintained.

Δt_r = Temp. rise on relief of residual tension.

Δt_w = Temp. rise to be expected from work done by tension.

$\frac{\Delta t_t + \Delta t_r}{\Delta t_w}$ = R = Ratio of heat evolved to work done.

Metal	$100\ \Delta l/l_0$ max.*	Δt_t	Δt_r	R
Steel	13.10	9.00	0.37	0.865
Cu	17.45	6.29	0.31	0.92
Al	23.06	5.68	0.28	0.93
Al, single crys	52.72	8.77	0.19	0.95

* R is independent of $\Delta\ l/l_0$ up to the maximum value studied.

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(For a key to the periodicals see end of volume)

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HEATS OF SOLUTION OF ORGANIC SUBSTANCES

ERNEST ANDERSON

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Tables 1 and 2 form a complete index to the whole.*

TABLE 1.—HEATS OF SOLUTION OF ORGANIC SUBSTANCES IN WATER

Q is expressed as kilojoules evolved per mole solute, at infinite dilution. These systems are arranged according to the C- arrangement (*v.* Vol. III, p. viii). Inorganic salts of organic acids will be found immediately following the acid.

Formula	Name	t, °C	Q	Lit. and table numbers
$CHCl_3$	Chloroform	16	9.2	(20)
CH_2N_2	Cyanamide		−15.1	(105)
CH_2O_2	Formic acid (solid)	7	− 9.83	(10)
	Formic acid (liquid)	7	0.33	(10); 5
CH_3NO_2	Nitromethane		− 2.5	(39)
CH_4N_2O	Urea		−15.1	(43, 111)
CH_4N_2S	Thiourea	10	−22.3	(111)
CH_4O	Methyl alcohol		8.37	(14, 68, 69, 70, 75, 81); 6
CH_5N	Methylamine			(47)
$CH_5N_3O_4$	Urea nitrate		−45.2	(111)
$CH_6N_4O_3$	Guanidine nitrate		−42.7	(111)
$C_2HBr_3O_2$	Tribromoacetic acid		4.69	(115); 5
$C_2HCl_3O_2$	Trichloroacetic acid (solid)		12.1	(106, 115); 5
	Trichloroacetic acid (liquid)	15	22.08	(115)
	Na trichloroacetate		7.28	(106)
$C_2H_2Br_2O_2$	Dibromoacetic acid		11.7	(115); 5
$C_2H_2Cl_2O_2$	Dichloroacetic acid		4.69	(106, 115); 5
$C_2H_2O_2$	Glyoxal		− 5.23	(66)
	Glyoxal bisulfite		−40.4	(66)
$C_2H_2O_4$	Oxalic acid		− 9.58	(96, 108)
$C_2H_2O_4.2H_2O$	Oxalic acid		−35.5	(96)
$C_2H_3BrO_2$	Bromoacetic acid		−12.8	(115); 5
$C_2H_3ClO_2$	Chloroacetic acid (solid)	16	−14.0	(106, 115)
	Chloroacetic acid (liquid)	16	1.12	(106, 115)
$C_2H_3Cl_3O_2$	Chloral hydrate		− 3.77	(20, 88, 122)
$C_2H_3NO_3$	Oxamic acid	12	−29	(111)
	K oxamate		−31.0	(110)
C_2H_4O	Acetaldehyde		15.1	(8)
$C_2H_4O_2$	Acetic acid (solid)	7	− 8.91	(10)
		14	− 9.42	(10)
	Acetic acid (liquid)	7	1.67	(37); 5
		23	1.00	(10)
$C_2H_4O_2$	Methyl formate	15	4.73	(41)
$C_2H_4O_3$	Glycolic acid		−11.55	(66)
	Ba glycolate		−21.26	(66)
	Ca glycolate		− 6.78	(66)
	Ca glycolate ($3H_2O$)		−29.55	(66)
	Ca glycolate ($5H_2O$)		−32.6	(66)
	Cu glycolate		− 6.78	(66)
	K glycolate		− 6.86	(66)
	K glycolate ($0.5H_2O$)		−19.7	(66)
	Mg glycolate		−18.41	(66)
	Na glycolate		−10.30	(66)
	Na glycolate ($0.5H_2O$)		−14.6	(66)
	NH_4 glycolate		−13.52	(66)
	Pb glycolate		−24.02	(66)
	Sr glycolate		− 5.02	(66)
	Zn glycolate		− 2.76	(66)
$C_2H_4O_4$	Glyoxylic acid	11	−10.5	(67)
	Ca glyoxylate		− 9.37	(67)
	Na glyoxylate		−20.1	(67)
C_2H_5NO	Acetamide	23	− 8.33	(122)
$C_2H_5NO_2$	Glycocoll		−14.98	(106)
$C_2H_5NO_3$	Ethyl nitrate		4.14	(15)
C_2H_6O	Ethyl alcohol	13	10.63	(14, 48, 75, 81, 138); 3, 6
C_2H_6O	Dimethyl ether	17	34.7	(21)

* The numbers in the last column not in parentheses are numbers of other tables in this section which should be consulted for further data.

TABLE 1.—(*Continued*)

Formula	Name	t, °C	Q	Lit. and table numbers
$C_2H_6O_2$	Glycol		7.1	(23, 73); 3
$C_2H_6N_2O_3$	Urea formate		−30.1	(111)
$C_2H_6O_4S$	Ethyl sulfuric acid			
	Ba ethylsulfate		2.9	(14)
	Ba ethylsulfate ($2H_2O$)		−18.0	(14)
	Na ethylsulfate		− 4.2	(14)
	Na ethylsulfate (H_2O)		−13.0	(14)
C_2H_7N	Ethylamine	19	26.49	(6, 22, 58)
C_2H_8ClN	Ethylamine hydrochloride		− 9.33	(87)
$C_2H_8N_2$	Ethylenediamine		31.8	(60)
$C_2H_{10}Cl_2N_2$	Ethylenediamine dihydrochloride		−31.60	(60)
$C_2H_{12}N_6O_4S$	Guanidine sulfate		−28.25	(111)
$C_3H_2Br_2O_4$	Dibromomalonic acid		8.45	(108)
	KH dibromomalonate		−23.4	(108)
	K_2 dibromomalonate		−41.60	(108)
$C_3H_3N_3O_3$	Cyanuric acid		*v.* p. 182	
$C_3H_4Br_2O_2$	α-Dibromopropionic acid	13	6.86	(125)
	K α-dibromopropionate		2.18	(125)
	K α-dibromopropionate (H_2O)		−12.1	(125)
$C_3H_4N_2O_2$	Hydantoin		−25.1	(111)
$C_3H_4O_4$	Malonic acid		−18.8	(108)
	Ag_2 malonate		−41.0	(108)
	KH malonate		−21.3	(108)
	K_2 malonate		8.8	(108)
	K_2 malonate ($2H_2O$)		−23.4	(108)
	LiH malonate		− 5.9	(108)
	Li_2 malonate		14.6	(108)
	NaH malonate		−25.5	(108)
	Na_2 malonate		13.0	(108)
	Na_2 malonate (H_2O)		6.3	(108)
	NH_4H malonate		−25.1	(108)
	$(NH_4)_2$ malonate		−10.5	(108)
$C_3H_4O_5$	Tartronic acid		−15.69	(108)
	KH tartronate	14	−31.4	(108)
	K_2 tartronate		−19.88	(108)
	Na_2 tartronate	10	−12.6	(108)
C_3H_5N	Propionitrile		− 3.26	(120)
$C_3H_6N_2O_2$	Acetylurea		−28.5	(110)
$C_3H_6N_2O_3$	Hydantoic acid		−27.2	(111)
C_3H_6O	Allyl alcohol		8.37	(14)
C_3H_6O	Propionaldehyde		17	(14)
C_3H_6O	Acetone		10.5	(14); 4
$C_3H_6O_2$	Propionic acid		2.59	(108); 5
	Ba propionate		28.75	(11)
	K propionate		12.64	(108)
	Na propionate		12.76	(108)
$C_3H_6O_2$	Ethyl formate	10	8.8	(41)
C_3H_7N	Allylamine		19.59	(58, 87)
C_3H_7NO	Propionamide	15	− 4	(35)
$C_3H_7NO_2$	Urethane	23	−15.9	(122)
$C_3H_8N_2O$	Ethylurea	14	− 9.6	(111)
$C_3H_8N_2O_3$	Urea acetate		−36.8	(111)
C_3H_8O	*n*-Propyl alcohol		12.76	(49, 70); 6
C_3H_8O	Isopropyl alcohol		15.74	(75, 76)
$C_3H_8O_2$	Methylal		13.4	(40)
$C_3H_8O_3$	Glycerol		6.3	(8, 14, 71, 72, 89, 100); 4
C_3H_9N	Propylamine		25.74	(58)
C_3H_9N	Trimethylamine		36.62	(22, 58)
$C_3H_{10}ClN$	Trimethylamine hydrochloride	18	− 2.1	(22)
$C_4H_2N_2O_4$	Alloxan		−17.6	(112)
$C_4H_4O_4$	Fumaric acid		−24.7	(83, 86)
$C_4H_4O_4$	Maleic acid		−18.58	(83, 86)
$C_4H_5NO_2$	Succinimide	22	−18.0	(122)
$C_4H_6N_4O_3$	Allantoin		−31.4	(110)
$C_4H_6O_4$	Succinic acid	11	−26.8	(54)
	KH succinate		−22.39	(108)
	KH succinate (H_2O)		−31.8	(54)

TABLE 1.—(*Continued*)

Formula	Name	t, °C	Q	Lit. and table numbers
$C_4H_6O_4$	K_2 succinate		0.8	(54)
	K_2 succinate (H_2O)		−14.2	(54)
	NaH succinate		−11.7	(108)
	Na_2 succinate		10.0	(108)
	Na_2 succinate ($6H_2O$)		−46.0	(54)
	NH_4H succinate		−20.5	(54)
	$(NH_4)_2$ succinate		−14.6	(108)
$C_4H_6O_4$	Isosuccinic acid	6	−14.31	(108)
	KH isosuccinate		−15.74	(108)
	KH isosuccinate (H_2O)		−19.08	(108)
	K_2 isosuccinate		13.06	(108)
	K_2 isosuccinate (H_2O)		8.16	(108)
	K_2 isosuccinate ($2H_2O$)		5.90	(108)
	Na_2 isosuccinate		20.5	(108)
$C_4H_6O_4$	Dimethyl oxalate		− 9.37	(18)
$C_4H_6O_5$	Malic acid	15	−13.8	(107, 108)
		20	−13.18	(85)
	KH malate		−24.3	(107, 108)
	KH malate (H_2O)		−27.6	(108)
	K_2 malate		− 6.49	(107, 108)
	NaH malate	21	− 6.95	(107, 108)
	NaH malate (H_2O)	18	−11.17	(108)
	Na_2 malate	21	7.45	(107, 108)
$C_4H_6O_6$	*d*-Tartaric acid		−14.44	(36)
	KH tartrate	12	−48.5	(95)
	K_2 tartrate		−14.90	(10)
	K_2 tartrate ($0.5H_2O$)		−23.27	(10)
	KSbO tartrate	12	−21.3	(91)
	KSbO tartrate ($0.5H_2O$)		−22.2	(91)
	NaH tartrate		−23.69	(10)
	NaH tartrate (H_2O)		−35.74	(10)
	NaK tartrate		− 7.83	(10)
	NaK tartrate ($4H_2O$)		−51.64	(10)
	Na_2 tartrate		− 4.69	(10)
	Na_2 tartrate ($2H_2O$)		−24.61	(10)
	dl-Tartaric acid		−22.68	(36, 108)
	dl-Tartaric acid (H_2O)		−28.88	(36)
	meso-Tartaric acid		−21.93	(36, 108)
$C_4H_7Cl_3O_2$	Chloral alcoholate		0.0	(24)
$C_4H_7NO_4$	Aspartic acid	16	−30.34	(32)
$C_4H_8O_2$	*n*-Butyric acid		5	
	Na *n*-butyrate		17.74	(11)
	Na *n*-butyrate ($3H_2O$)		14.40	(11)
$C_4H_8O_2$	Isobutyric acid		4.2	(84)
	Ca isobutyrate ($5H_2O$)		13.0	(53)
$C_4H_8O_2$	Ethyl acetate	15	12.81	(18)
$C_4H_{10}N_4O_6$	Urea oxalate	17	−74.5	(111)
$C_4H_{10}O$	Isobutyl alcohol		12.1	(14, 70)
$C_4H_{10}O$	Trimethyl carbinol	15	13.52	(77)
$C_4H_{10}O$	Ethyl ether	13	−24.7	(17)
$C_4H_{10}O_4$	Erythritol		−22.2	(38, 74)
$C_4H_{11}N$	Diethylamine		34.40	(58)
$C_4H_{11}N$	Isobutylamine		25	(58)
$C_4H_{12}ClN$	Diethylamine hydrochloride		− 6.24	(7)
$C_5H_4N_4O_2S$	Thiouric acid ($1.5H_2O$)		−44.8	(112)
	K_2 thiourate		−69.5	(112)
	Na_2 thiourate		−26.8	(112)
$C_5H_4N_4O_3$	Uric acid			
	K urate		−35.2	(112)
C_5H_5N	Pyridine	22	8.87	(30, 58)
$C_5H_9NO_2$	Dimethylparabanic acid		−19.46	(110)
$C_5H_6N_4O_4$	Pseudouric acid			
	K pseudourate (H_2O)		−28.9	(112)
$C_5H_6O_4$	Citraconic acid		−11.7	(83)
$C_5H_6O_4$	Itaconic acid		−24.78	(83)
$C_5H_6O_4$	Mesaconic acid	19	−23.0	(83)
$C_5H_8O_2$	Acetylacetone		− 2.68	(61, 120)
$C_5H_8O_3$	Levulinic acid (solid)		−15.02	(124)
	Levulinic acid (liquid)		− 5.82	(124)
	K levulinate		6.03	(124)
	Na levulinate		5.65	(124)
$C_5H_8O_4$	Glutaric acid		−22.6	(108)
	KH glutarate		−18.58	(108)
	K_2 glutarate		19.13	(108)
$C_5H_8O_4$	Pyrotartaric acid		−21	(108)
	KH pyrotartrate		−13.0	(108)
	KH pyrotartrate (H_2O)		−17.6	(108)
	K_2 pyrotartrate		19.3	(108)

TABLE 1.—(*Continued*)

Formula	Name	t, °C	Q	Lit. and table numbers
$C_5H_8O_4$	Monoethyl malonate		2.5	(108)
	K ethyl malonate		− 2.72	(108)
$C_5H_{10}O_2$	Isovaleric acid		2.9	(12)
$C_5H_{10}O_2$	Trimethylacetic acid			
	K trimethylacetate	16	30.76	(10)
$C_5H_{11}N$	Piperidine	21	27.04	(30, 58)
$C_5H_{12}ClN$	Piperidine hydrochloride		− 4	(59)
$C_5H_{12}O$	Isoamyl alcohol		11.7	(14, 70)
$C_5H_{13}N$	Amylamine		21.13	(58, 87)
$C_5H_{14}ClN$	Amylamine hydrochloride		− 5.73	(87)
$C_6H_3Br_3O_2$	1, 3-Dihydroxy-2, 4, 6-tribromobenzene		− 9.2	(45)
$C_6H_3N_3O_7$	Picric acid		−29.7	(9)
	Ba picrate		−19.7	(129)
	Ba picrate (H_2O)		−39.3	(129)
	Ba picrate ($6H_2O$)		−61.73	(129)
	Ca picrate		9.2	(129)
	Ca picrate ($6H_2O$)		−62.4	(129)
	Cu picrate		13.8	(129)
	Cu picrate ($8H_2O$)		−73.7	(129)
	K picrate		−42	(9, 129)
	Mg picrate		61.5	(129)
	Mg picrate ($8H_2O$)		−66.5	(129)
	Na picrate		−26.95	(9, 129)
	NH_4 picrate		−36.4	(9, 129)
	Pb picrate		−29.7	(129)
	Pb picrate ($2H_2O$)		−55.2	(129)
	Sr picrate		3.3	(129)
	Sr picrate ($6H_2O$)		−60.3	(129)
	Zn picrate		48.1	(129)
	Zn picrate ($8H_2O$)		−66.5	(129)
$C_6H_4O_2$	Quinone		−16.7	(44)
C_6H_5BrO	*p*-Bromophenol		−15.5	(135)
$C_6H_5ClN_2$	Phenyldiazonium chloride		− 7.70	(123)
$C_6H_5NO_3$	*o*-Nitrophenol		−26.4	(1)
	Na *o*-nitrophenate		− 7.5	(1)
$C_6H_5NO_3$	*m*-Nitrophenol		−21.8	(1)
	Na *m*-nitrophenate		13.0	(106)
$C_6H_5NO_3$	*p*-Nitrophenol		−18.8	(1)
	Na *p*-nitrophenate		11.3	(1)
$C_6H_6O_2$	Catechol		−14.6	(44, 78)
$C_6H_6O_2$	Resorcinol	10	−16.57	(44, 78, 88, 122)
$C_6H_6O_2$	Hydroquinol		−18.4	(44, 78)
$C_6H_6O_3$	Phloroglucinol		− 6.91	(44)
	Phloroglucinol (H_2O)		−28.0	(44)
$C_6H_6O_3$	Pyrogallol		−15.5	(44, 78, 88)
C_6H_6ClN	*o*-Chloroaniline		− 2.34	(106)
C_6H_6ClN	*m*-Chloroaniline		− 3.47	(106)
C_6H_6ClN	*p*-Chloroaniline		−21.39	(106)
$C_6H_6N_2O_2$	*p*-Nitroaniline		−15.65	(106)
C_6H_6O	Phenol (solid)		−10.9	(8, 78, 88, 100)
$C_6H_6O_3S$	Benzenesulfonic acid			
	Ba benzenesulfonate		10.9	(13)
	Ba benzenesulfonate ($3H_2O$)		−10.9	(13)
	Na benzenesulfonate	14	− 3.3	(13)
	Na benzenesulfonate ($2H_2O$)		−14.2	(13)
$C_6H_6O_4S$	*o*-Phenolsulfonic acid			
	Ba *o*-phenolsulfonate (H_2O)		−56.5	(2)
	K *o*-phenolsulfonate ($2H_2O$)		−40.6	(2)
$C_6H_6O_6$	Aconitic acid		−17.6	(7)
$C_6H_6O_7S_2$	Phenol-2, 4-disulfonate			
	Ba phenol-2, 4-disulfonate ($4H_2O$)		−33.1	(3)
$C_6H_7Cl_2N$	*o*-Chloroaniline hydrochloride		−18.33	(106)
$C_6H_7Cl_2N$	*m*-Chloroaniline hydrochloride		−16.45	(106)
$C_6H_7Cl_2N$	*p*-Chloroaniline hydrochloride		−14.61	(106)
C_6H_7N	Aniline	16	− 0.75	(29)
		24	− 2.30	(29)
C_6H_8ClN	Aniline hydrochloride		−11.43	(29)
$C_6H_8N_2$	Phenylhydrazine (liquid)	21	1.21	(33)
	Phenylhydrazine (H_2O)		−31.0	(33)
$C_6H_8N_2$	*m*-Phenylenediamine		−13.4	(133)
$C_6H_8N_2$	*p*-Phenylenediamine		−15.9	(132)
$C_6H_8N_2O_3$	Aniline nitrate		−28.17	(29)

TABLE 1.—(*Continued*)

Formula	Name	*t*, °C	*Q*	Lit. and table numbers
$C_6H_8O_6$	Tricarballylic acid		−27.2	(108)
	KH_2 tricarballylate		−28.0	(108)
	K_2H tricarballylate		−16.7	(108)
	K_3 tricarballylate		13.0	(108)
	Na_3 tricarballylate		27.6	(108)
$C_6H_8O_7$	Citric acid		−22.6	(88, 108)
	KH_2 citrate		−33.5	(108)
	K_2H citrate		−28.0	(108)
	K_3 citrate		11.8	(108)
	NaH_2 citrate		−26.57	(108)
	Na_2H citrate		− 5.11	(108)
	Na_3 citrate		22.05	(108)
$C_6H_9ClN_2$	Phenylhydrazine hydrochloride		−24.94	(114)
$C_6H_{10}O_3$	Ethyl acetoacetate		5.27	(80)
	Na ethyl acetoacetate		18.4	(79)
$C_6H_{10}O_4$	Diethyl oxalate	15	12.89	(18)
$C_6H_{11}Cl_3N_2$	*o*-Phenylenediamine trihydrochloride ($5H_2O$)		−34.3	(133)
$C_6H_{12}N_4$	Hexamethylenetetramine		20.1	(62)
$C_6H_{12}O$	Cyclohexanol (solid)		8.12	(82)
	Cyclohexanol (liquid)		9.8	(82)
$C_6H_{12}O_6$	Inositol	18	−14.15	(31)
$C_6H_{13}ClN_4$	Hexamethylenetetramine hydrochloride	15	−16.49	(62)
$C_6H_{13}N_5O_3$	Hexamethylenetetramine nitrate		−23.02	(62)
$C_6H_{14}N_4O_6S$	Hexamethylenetetramine sulfate		− 6.70	(62)
$C_6H_{14}N_8O_6$	Hexamethylenetetramine dinitrate		−59.8	(62)
$C_6H_{14}O_6$	Dulcitol		−24.7	(14)
$C_6H_{14}O_6$	Mannitol	23	−22.01	(14, 122)
$C_6H_{16}IS$	Triethylsulfonium iodide		−24.06	(7)
$C_6H_{15}N$	Dipropylamine		31.60	(58)
$C_6H_{15}N$	Triethylamine		42	(58, 87)
$C_6H_{15}ClN$	Triethylamine hydrochloride		− 2.22	(87)
$C_7H_4O_7$	Meconic acid		−38.1	(27)
$C_7H_5ClO_2$	*o*-Chlorobenzoic acid		−26.9	(116)
	K *o*-chlorobenzoate ($0.5H_2O$)		1.51	(116)
$C_7H_5NO_4$	*o*-Nitrobenzoic acid		−22.2	(1, 90)
	Na *o*-nitrobenzoate		16.3	(1)
$C_7H_5NO_4$	*m*-Nitrobenzoic acid		−23.4	(1, 106)
	Na *m*-nitrobenzoate		− 4.6	(1, 106)
$C_7H_5NO_4$	*p*-Nitrobenzoic acid		−37.2	(1)
	Na *p*-nitrobenzoate		− 4.19	(1)
$C_7H_6O_2$	Salicylaldehyde		0.4	(25)
$C_7H_6O_2$	*p*-Hydroxybenzaldehyde		−20.5	(25)
$C_7H_6O_2$	Benzoic acid		−27.2	(9, 108)
	Ca benzoate		19.7	(9)
	K benzoate		− 6.3	(9)
	Na benzoate		3.3	(9)
	NH_4 benzoate		−11.3	(9)
$C_7H_6O_3$	*o*-Hydroxybenzoic acid		−26.57	(46)
	Na *o*-hydroxybenzoate		− 9.17	(108)
$C_7H_6O_3$	*m*-Hydroxybenzoic acid		−25.86	(46)
$C_7H_6O_3$	*p*-Hydroxybenzoic acid		−24.19	(46)
	p-Hydroxybenzoic acid (H_2O)		−32.31	(46)
$C_7H_6O_4$	3, 4-Dihydroxybenzoic acid (H_2O)	17	−29.7	(25)
$C_7H_6O_5$	Gallic acid (H_2O)		−29.7	(25)
$C_7H_7NO_2$	*o*-Hydroxybenzamide		−18.16	(1)
	Na *o*-hydroxybenzamide		1.46	(1)
$C_7H_7NO_2$	*m*-Hydroxybenzamide		−17.41	(106)
	Na *m*-hydroxybenzamide		5.9	(106)
$C_7H_7NO_2$	*p*-Hydroxybenzamide		−22.56	(1)
	Na *p*-hydroxybenzamide		8.0	(1)
$C_7H_8ClNO_2$	*m*-Hydroxybenzamide hydrochloride		−29.3	(106)
C_7H_8O	*o*-Cresol		− 8.8	(28)
C_7H_8O	*p*-Cresol		− 8.8	(28)
$C_7H_8O_2$	Orcinol		−10.9	(44)
	Orcinol (H_2O)		−22.6	(44)
$C_7H_8O_2$	*o*-Hydroxybenzyl alcohol		−13.4	(25)
$C_7H_8O_3S$	*p*-Toluenesulfonic acid			
	K *p*-toluenesulfonate		−20.9	(26)
C_7H_9N	Benzylamine		10.71	(58, 87)

TABLE 1.—(*Continued*)

Formula	Name	*t*, °C	*Q*	Lit. and table numbers
C_7H_9N	*p*-Toluidine		−18.8	(7)
$C_7H_9NO_2$	Pyridine acetate		8.069	(109)
$C_7H_{10}ClN$	Benzylamine hydrochloride		−16.03	(87)
$C_7H_{10}ClN$	*p*-Toluidine hydrochloride		−13.60	(7)
$C_7H_{12}O_6$	Quinic acid	17	−12.76	(27)
$C_8H_6N_4O_8$	Alloxantin ($2H_2O$)		−44.4	(112)
$C_8H_6O_4$	Phthalic acid		−20.38	(57)
	Na_2 phthalate		1.00	(57)
	Na_2 isophthalate		− 3.3	(57)
	Na_2 terephthalate		− 2.5	(57)
$C_8H_6O_4$	Piperonylic acid		−38.1	(26)
$C_8H_8O_3$	Anisic acid		−33.1	(26)
$C_8H_8O_3$	Mandelic acid	18	−12.93	(26)
$C_8H_8O_3$	Vanillin		−21.8	(26)
$C_8H_8O_4$	Vanillic acid	14	−21.59	(26)
$C_8H_{10}N_4O_2$	Caffeine		−11.47	(112)
	Caffeine (H_2O)		−18.67	(112)
$C_8H_{11}NO_4$	Diethyl cyanomalonate		10.0	(93)
	Ba ethyl cyanomalonate			
	Ba ethyl cyanomalonate ($4H_2O$)		−20.5	(93)
	Na ethyl cyanomalonate		−10.9	(93)
$C_8H_{16}O_2$	Caprylic acid		0.67	(108)
$C_8H_{19}N$	Diisobutylamine		29.50	(58)
$C_9H_{10}O_4$	Veratric acid		−25.5	(26)
$C_{10}H_{11}NO_4$	Nitrocumic acid			
	Na nitrocumate		− 5.0	(1)
$C_{10}H_{12}O_2$	Cumic acid			
	Na cumate		15.9	(1)
$C_{10}H_{16}NO_2$	Nitrocamphor		− 7.5	(42)
	Hydrated nitrocamphor		−11.7	(42)
$C_{10}H_{16}Cl_2N_2$	Nicotine dihydrochloride		27.45	(58)
$C_{10}H_{16}O_2$	Campholenic acid		−13.4	(34)
$C_{10}H_{16}O_4$	Camphoric acid		− 2.1	(27)
$C_{10}H_{20}O$	Menthol		0	(88)
$C_{12}H_6O_{12}$	Mellitic acid		15.36	(27)
$C_{12}H_{10}O_4$	Piperic acid		−43.9	(26)
$C_{12}H_{13}ClN_2$	Benzidine hydrochloride		−31.4	(114)
$C_{12}H_{14}Cl_2N_2$	Benzidine dihydrochloride		−24.7	(114)
$C_{12}H_{16}N_2O_4S$	Aniline sulfate		−19.38	(29)
$C_{12}H_{20}O_{10}$	Dextrin		− 1.12	(136)
$C_{12}H_{22}O_{11}$	Lactose		10.5	(96)
	Lactose (H_2O)		−15.5	(96)
$C_{12}H_{22}O_{11}$	Sucrose	23	− 5.52	(14, 100, 122)
$C_{13}H_{18}O_7$	Salicin	18	−12.26	(26)
$C_{14}H_{10}N_2O_4$	*m*, *m*′-Azobenzoic acid		18.4	(1)
	Na_2 *m*, *m*′-azobenzoate		− 7.5	(1)
	Na_2 *p*, *p*′-azobenzoate			(100)
$C_{14}H_{10}O_9$	Tannic acid			
$C_{17}H_{22}N_2$	Tetramethyldiaminodiphenylmethane	18	0.25	(134)
$C_{18}H_{32}O_{16}$	Raffinose		35.2	(38)
	Raffinose ($5H_2O$)		−40.6	(38)
$C_{20}H_{22}N_2O_4$	Azocumic acid		28.9	(1)
	Na_2 azocumate			
$C_{20}H_{24}N_2O_4$	Hydrazocumic acid		43.1	(1)
	Na_2 hydrazocumate		− 0.4	(136)
$C_{36}H_{62}O_{31}$	Inulin			

TABLE 2.—HEATS OF SOLUTION OF BINARY ORGANIC SYSTEMS

℄-Table.—℄-Arrangement (*v.* Vol. III, p. viii)

The B-component where italicized is the solute, and otherwise is the solvent. *Q* is expressed in kilojoules evolved per mole solute, dissolved in more than one mole solvent; at room temperature where not given.

B-Component		*Q*	Lit. and Table No.*
Formula	Name (and temp., °C)		
	CCl_4		
CS_2	Carbon bisulfide	− 1.76	(127); 3
$CHCl_3$	*Chloroform*	0.67	3 (127)
CH_4O	Methyl alcohol		

* The numbers not in parentheses are numbers of other tables in this section which should be consulted for further data.

TABLE 2.—(*Continued*)

B-Component		Q	Lit. and Table No.*
Formula	Name (and temp., °C)		
	CCl_4.—(*Continued*)		
CH_4O	*Methyl alcohol*	− 6.7	(127)
$C_2H_4Br_2$	Ethylene bromide		3
$C_2H_4O_2$	Acetic acid	− 0.8	(127)
$C_2H_4O_2$	*Acetic acid*	− 1.88	(127)
C_2H_6O	Ethyl alcohol	0.88	(127)
C_3H_6O	*Acetone*	− 1.7	(127)
C_3H_8O	Propyl alcohol	0.8	(127)
$C_4H_8O_2$	*Ethyl acetate*	− 0.29	(127, 130); 3
$C_4H_{10}O$	Isobutyl alcohol	− 1.3	(127)
$C_4H_{10}O$	*Ethyl ether*	2.1	(127)
C_5H_5N	Pyridine	1.3	(127)
C_5H_5N	*Pyridine*	− 1.3	(127)
C_6H_6	Benzene	− 0.67	(127); 3
C_6H_6	*Benzene*	− 0.50	(127); 3, 4
C_6H_7N	Aniline	− 4.52	(127); 3
C_6H_7N	*Aniline*	− 8.8	(127)
$C_7H_6O_2$	*Benzoic acid*	−14.6	(127)
$C_7H_6O_3$	*Salicylic acid*	−11.3	(127)
C_7H_8	*Toluene*		3, 4
$C_7H_9NO_2$	*Pyridine acetate*	− 0.448	(109)
C_7H_{16}	Heptane	− 0.71	(127)
C_7H_{16}	*Heptane*	− 1.00	(127)
$C_{12}H_{24}O_2$	*Lauric acid*	−35.6	(127)
$C_{22}H_{42}O_2$	*Erucic acid*	−50.6	(127)
	CS_2		
$CHCl_3$	*Chloroform*	− 2.43	(127); 3, 4
$C_2H_4Br_2$	Ethylene bromide		3
C_2H_6O	*Ethyl alcohol*	− 6.7	(127); 4
C_3H_6O	*Acetone*	− 7.5	(127); 4
$C_4H_8O_2$	*Ethyl acetate*	− 6.53	(127); 3
$C_4H_{10}O$	*Ethyl ether*	− 4.2	(127); 3
C_6H_6	*Benzene*	− 2.80	(127); 3, 4
$C_6H_{12}O_3$	Paraldehyde		3
C_7H_8	*Toluene*		4
C_7H_{16}	*Heptane*	− 2.85	(127)
$C_{10}H_7NO_2$	*Nitronaphthalene*	−22.68	(88)
$C_{10}H_8$	*Naphthalene*	−20.9	(88)
$C_{10}H_{16}$	Pinene		3
$C_{12}H_{10}N_2$	*Azobenzene*	−20.84	(88)
$C_{12}H_{11}N$	*Diphenylamine*	−15.0	(88)
	$CHBr_3$, Bromoform		
C_7H_8	*Toluene*		3
	$CHCl_3$, Chloroform		
CH_4O	Methyl alcohol	4.77	(127); 3
$C_2H_3Cl_3O_2$	*Chloral hydrate* (22°)	−25.07	(122)
$C_2H_4Br_2$	Ethylene bromide		3
C_2H_4O	Acetaldehyde		3
$C_2H_4O_2$	Acetic acid	2.43	(127)
$C_2H_4O_2$	*Acetic acid*	2.1	(127)
C_2H_6O	Ethyl alcohol	6.03	(127); 3
C_3H_6O	Acetone	4.85	(127); 3, 4
C_3H_6O	*Acetone*	8.0	(127, 128)
$C_3H_7NO_2$	*Urethane* (24°)	−19.3	(122)

* The numbers not in parentheses are numbers of other tables in this section which should be consulted for further data.

TABLE 2.—(*Continued*)

B-Component		Q	Lit. and Table No.*
Formula	Name (and temp., °C)		
	$CHCl_3$.—(*Continued*)		
C_3H_8O	*n*-Propyl alcohol	4.69	(127); 3
$C_4H_8O_2$	Ethyl acetate	5.61	(127); 3
$C_4H_8O_2$	*Ethyl acetate*	9.08	(127)
$C_4H_{10}O$	Ethyl ether	8.41	(127); 3
$C_4H_{10}O$	*Ethyl ether*	8.8	(127); 4
$C_4H_{10}O$	Isobutyl alcohol		3
C_5H_5N	Pyridine	6.19	(127)
C_5H_5N	*Pyridine*	7.70	(127)
$C_5H_{12}O$	Isoamyl alcohol		3
C_6H_5Cl	*Chlorobenzene*		3
$C_6H_5NO_3$	*o-Nitrophenol*	−17.03	(88)
C_6H_6	Benzene	1.00	(127); 3
C_6H_6	*Benzene*	1.80	(127, 130); 3, 4
C_6H_6O	*Phenol*	−16.7	(127)
C_6H_7N	Aniline	0	(127)
C_6H_7N	*Aniline*	− 1.3	(127)
C_6H_{10}	*Cyclohexene*		3
C_6H_{12}	*Cyclohexane*		3
$C_6H_{12}O_3$	Paraldehyde		3
$C_7H_6O_2$	*Benzoic acid*	−13.4	(127)
C_7H_8	*Toluene*		3
C_7H_9N	*p-Toluidine* (23°)	−14.61	(122)
$C_7H_9NO_2$	*Pyridine acetate*	5.047	(109)
C_7H_{16}	*Heptane*	3.06	(127)
C_8H_9NO	*Acetanilide* (25°)	−18.4	(122)
C_8H_{10}	*p-Xylene*		3
C_8H_{18}	Octane	− 2.34	(127)
$C_{10}H_7NO_2$	*Nitronaphthalene*	−17.45	(88)
$C_{10}H_8$	*Naphthalene* (23°)	−16.11	(122)
$C_{12}H_{10}$	*Acenaphthene* (21°)	−18.8	(122)
	CH_4N_2O, Urea		
C_2H_6O	Ethyl alcohol (24°)	−15.11	(122)
	CH_2O_2, Formic acid		
$C_2H_4O_2$	Acetic acid		3
	CH_4O, Methyl alcohol		
$C_2H_2O_4$	*Oxalic acid*	− 3.64	(126)
$C_2H_2O_4$	*Oxalic acid* ($2H_2O$)	−21.8	(126)
$C_2H_4O_2$	Acetic acid	0	(127)
$C_2H_4O_2$	*Acetic acid*	0.79	(127)
C_2H_6O	Ethyl alcohol		3, 4
C_3H_6O	*Acetone*	− 2.09	(127); 3
$C_3H_7NO_2$	*Urethane* (24°)	−18.20	(122)
C_3H_8O	*n*-Propyl alcohol		3, 4
C_3H_8O	Isopropyl alcohol		3
$C_4H_8O_2$	Ethyl acetate	− 5.44	(127)
$C_4H_8O_2$	*Ethyl acetate*	− 3.10	(127)
$C_4H_{10}O$	Ethyl ether	− 2.5	(127); 3
$C_4H_{10}O$	Isobutyl alcohol		3
C_5H_5N	Pyridine	2.30	(127)
C_5H_5N	*Pyridine*	4.19	(127)
$C_5H_{12}O$	*Isoamyl alcohol*		3
$C_6H_5NO_3$	*o-Nitrophenol*	−20.1	(127)
C_6H_6	Benzene	−11.7	(127)
C_6H_6	*Benzene*	− 1.51	(127); 4
$C_6H_6O_2$	*Resorcinol*	0.84	(127)

TABLE 2.—(*Continued*)

B-Component		Q	Lit. and Table No.*
Formula	Name (and temp.,°C)		
	CH_4O.—(*Continued*)		
C_6H_7N	Aniline	0.08	(127); 3
C_6H_7N	*Aniline*	2.85	(127)
$C_7H_5NO_4$	*o-Nitrobenzoic acid*	−17.2	(127)
$C_7H_5NO_4$	*m-Nitrobenzoic acid*	−15.1	(127)
$C_7H_6O_2$	*Benzoic acid* (13°)	−12.1	(126, 127)
$C_7H_6O_3$	*Salicylic acid*	−13.0	(126, 127)
$C_7H_6O_3$	*m-Hydroxybenzoic acid*	− 8.79	(127)
$C_7H_7NO_2$	*o-Aminobenzoic acid*	−12.6	(127)
$C_7H_7NO_2$	*m-Aminobenzoic acid*	−19.7	(127)
$C_7H_7NO_2$	*p-Aminobenzoic acid*	− 9.21	(127)
C_7H_8	Toluene	− 4.60	(127)
C_7H_{16}	Heptane	− 9.63	(127)
C_7H_{16}	*Heptane*	− 4.65	(127)
C_8H_9NO	*Acetanilide* (24°)	−18.8	(122)
$C_9H_8O_2$	*Cinnamic acid* (13°)	−15.9	(126)
$C_{10}H_8$	*Naphthalene* (24°)	−17.70	(122)
$C_{12}H_{10}$	*Acenaphthene* (24°)	−25.9	(122)
$C_{12}H_{24}O_2$	*Lauric acid*	−41.4	(127)
$C_{14}H_{28}O_2$	*Myristic acid*	−51.06	(127)
$C_{16}H_{32}O_2$	*Palmitic acid*	−61.52	(127)
$C_{19}H_{16}$	*Triphenylmethane*	−24.6	(127)
	$C_2H_2O_4$, Oxalic acid		
C_2H_6O	Ethyl alcohol	− 5.31	(126)
C_3H_8O	Propyl alcohol	− 7.87	(126)
	$C_2H_2O_4.2H_2O$, Oxalic acid		
C_2H_6O	Ethyl alcohol	−23.4	(126)
C_3H_8O	Propyl alcohol	−27.6	(126)
	$C_2H_3Cl_3O_2$, Chloral hydrate		
C_2H_6O	Ethyl alcohol (24°)	− 4.73	(88, 122)
C_3H_6O	Acetone	− 2.89	(88)
$C_4H_{10}O$	Ethyl ether	0	(88)
C_7H_8	Toluene (24°)	−31.4	(122)
	$C_2H_4Br_2$, Ethylene bromide		
$C_2H_4Cl_2$	*Ethylene chloride*		3
$C_2H_4O_2$	Acetic acid		5
$C_2H_4O_2$	*Acetic acid*		5
C_6H_5Cl	*Chlorobenzene*		3
C_6H_6	*Benzene*		3
C_6H_{10}	*Cyclohexene*		3
C_6H_{12}	*Cyclohexane*		3
C_6H_{14}	*n-Hexane*		3
C_7H_8	*Toluene*		3
C_8H_{10}	*p-Xylene*		3
C_9H_{12}	*Mesitylene*		3
$C_{10}H_{14}$	*p-Cymene*		3
	$C_2H_4Cl_2$, Ethylene chloride		
C_6H_6	*Benzene*		3
C_7H_8	*Toluene*		3
	C_2H_4O, Acetaldehyde		
C_2H_6O	Ethyl alcohol		3
$C_4H_{10}O$	*Ethyl ether*		3
	$C_2H_4O_2$, Acetic acid		
C_2H_6O	Ethyl alcohol	− 1.05	(7)
C_2H_6O	*Ethyl alcohol*	− 2.01	(127)
C_3H_6O	Acetone	1.38	(127)
C_3H_6O	*Acetone*	0.84	(127)
$C_3H_6O_3$	Lactic acid		3
C_3H_8O	Propyl alcohol	− 1.42	(127)

* The numbers not in parentheses are numbers of other tables in this section which should be consulted for further data.

TABLE 2.—(*Continued*)

B-Component		Q	Lit. and Table No.*
Formula	Name (and temp., °C)		
	$C_2H_4O_2$.—(*Continued*)		
C_3H_8O	*Propyl alcohol*	− 3.06	(127)
$C_4H_8O_2$	Isobutyric acid		3
$C_4H_8O_2$	*Ethyl acetate*	0.54	(127)
$C_4H_{10}O$	*Ethyl ether*	1.67	(127)
$C_4H_{10}O$	Isobutyl alcohol	− 2.76	(127)
C_5H_5N	*Pyridine*	27.2	(127)
C_6H_6	Benzene	− 1.88	(127); 5
C_6H_6	*Benzene*	− 2.26	(127); 3, 4, 5
C_6H_6O	*Phenol*	−10.00	(88)
C_6H_{12}	*Cyclohexane*		3
C_6H_7N	*Aniline*	28.9	(127)
C_7H_8	Toluene	− 1.3	(4, 127); 3
C_7H_{16}	*Heptane*	− 5.40	(127)
$C_{10}H_8$	*Naphthalene*	−17.45	(88)
	C_2H_5NO, Acetamide		
C_2H_6O	Ethyl alcohol (23°)	−15.11	(122)
	C_2H_6O, Ethyl alcohol		
C_3H_6O	Acetone	− 5.11	(127); 3
$C_3H_7NO_2$	*Urethane* (24°)	−19.80	(122)
C_3H_8O	*n*-Propyl alcohol		3, 4
$C_3H_8O_3$	*Glycerol* (24°)	− 3.18	(65)
$C_4H_5NO_2$	*Succinimide* (22°)	−22.85	(122)
$C_4H_8O_2$	Ethyl acetate	− 7.53	(127)
$C_4H_8O_2$	*Ethyl acetate*	− 4.81	(127); 3
$C_4H_{10}O$	Ethyl ether	− 3.8	(127); 3
$C_4H_{10}O$	Isobutyl alcohol		3
C_5H_5N	Pyridine	0.54	(127)
C_5H_5N	*Pyridine*	2.26	(127)
$C_5H_{12}O$	Isoamyl alcohol		3
$C_6H_4N_2O_4$	*m-Dinitrobenzene*	−17.66	(88)
C_6H_6	Benzene	−16.7	(127); 4
C_6H_6	*Benzene*	− 1.51	(127); 3, 5
C_6H_6O	*Phenol*	− 2.5	(88, 127)
$C_6H_6O_2$	*Resorcinol* (23°)	2.89	(88, 122, 127)
$C_6H_6O_3$	*Pyrogallol*	3.60	(88)
C_6H_7N	Aniline	− 2.26	(127)
C_6H_7N	*Aniline*	1.00	(127)
$C_6H_8O_7$	*Citric acid*	−17.87	(88)
$C_6H_{15}O_4P$	*Triethyl phosphate*	− 0.8	(52)
$C_7H_5NO_4$	*m-Nitrobenzoic acid*	−12.1	(127)
$C_7H_6O_2$	*Benzoic acid*	−12.6	(126, 127)
$C_7H_6O_3$	*Salicylic acid*	−11.3	(126, 127)
$C_7H_6O_3$	*m-Hydroxybenzoic acid*	− 6.70	(127)
C_7H_7NO	*Benzamide* (24°)	−17.74	(122)
$C_7H_7NO_2$	*o-Aminobenzoic acid*	−11.3	(127)
$C_7H_7NO_2$	*m-Aminobenzoic acid*	−18.4	(127)
$C_7H_7NO_2$	*p-Aminobenzoic acid*	− 7.53	(127)
C_7H_9N	*p-Toluidine* (24°)	−15.28	(122)
C_7H_{16}	Heptane	− 3.3	(127)
C_7H_{16}	*Heptane*	− 2.64	(127)
C_8H_9NO	*Acetanilide* (23°)	−17.6	(122)
$C_9H_8O_2$	*Cinnamic acid*	−15.5	(126)
$C_{10}H_8$	*Naphthalene* (24°)	−20.34	(88, 122, 127)
$C_{10}H_{14}O$	*Thymol*	− 8.79	(88)
$C_{10}H_{20}O$	*Menthol*	− 7.91	(88)
$C_{12}H_{10}$	*Acenaphthene* (24°)	−24.7	(122)

TABLE 2.—(*Continued*)

B-Component Formula	B-Component Name (and temp., °C)	Q	Lit. and Table No.*
	C_2H_6O.—(*Continued*)		
$C_{12}H_{10}$	*Diphenyl*	−17.79	(88)
$C_{12}H_{10}N_2$	*Azobenzene*	−21.97	(88)
$C_{12}H_{24}O_2$	*Lauric acid*	−40.6	(127)
$C_{14}H_{10}$	*Phenanthrene* (24°)	−18.04	(122)
$C_{22}H_{42}O_2$	*Erucic acid*	−56.08	(127)
	C_3H_6O, Acetone		
$C_3H_7NO_2$	*Urethane*	−15.86	(88)
C_3H_8O	Isopropyl alcohol		(112.5)
$C_4H_8O_2$	*Ethyl acetate*	− 0.63	(127); 3
$C_4H_{10}O$	*Ethyl ether*		3
C_6H_5ClO	*o*-Chlorophenol		4
C_6H_6	Benzene	− 1.3	(127)
C_6H_6	*Benzene*	− 1.09	(127)
C_6H_6O	*Phenol*	− 0.59	(88)
$C_6H_6O_2$	*Resorcinol*	4.19	(127)
$C_6H_6O_3$	*Pyrogallol*	5.82	(88)
C_6H_7N	*Aniline*	5.44	(127)
$C_6H_8O_7$	*Citric acid*	−13.4	(88)
$C_7H_6O_2$	*Benzoic acid*	−12.1	(127)
$C_7H_6O_3$	*Salicylic acid*	−10.9	(127)
$C_7H_9NO_2$	*Pyridine acetate*	− 1.385	(109)
C_7H_{16}	*Heptane*	− 7.20	(127)
$C_{10}H_7NO_2$	*Nitronaphthalene*	−29.17	(88)
$C_{10}H_8$	*Naphthalene*	−18.29	(88)
$C_{10}H_9N$	*α-Naphthylamine*	−10.84	(88)
$C_{10}H_9N$	*β-Naphthylamine*	−15.61	(88)
$C_{12}H_{10}$	*Diphenyl*	−18.71	(88)
$C_{12}H_{10}N_2$	*Azobenzene*	−23.10	(88)
$C_{12}H_{11}N$	*Diphenylamine*	−13.52	(88)
$C_{22}H_{42}O_2$	*Erucic acid*	−63.6	(127)
	$C_3H_6O_2$, Methyl acetate		
$C_4H_8O_2$	*Ethyl acetate*		3, 4
C_6H_6	*Benzene*		4
	$C_3H_7NO_2$, Urethane		
C_3H_8O	Propyl alcohol (25°)	−25.32	(122)
C_7H_8	Toluene (23°)	−26.8	(122)
	C_3H_8O, *n*-Propyl alcohol		
$C_4H_8O_2$	*Ethyl acetate*	− 5.48	(127); 3
$C_4H_{10}O$	*Ethyl ether*		3
$C_4H_{10}O$	Isobutyl alcohol		3
C_5H_5N	Pyridine	0.17	(127)
$C_5H_{12}O$	Isoamyl alcohol		3
C_6H_6	Benzene	−14.6	(127)
C_6H_6	*Benzene*	− 2.26	(127); 4
$C_6H_6O_2$	*Resorcinol*	− 0.84	(127)
C_6H_7N	*Aniline*	− 1.51	(127); 3
$C_7H_5NO_4$	*o-Nitrobenzoic acid*	−20.9	(127)
$C_7H_6O_2$	*Benzoic acid*	−14.2	(126, 127)
$C_7H_6O_3$	*Salicylic acid*	−13.8	(126, 127)
C_7H_{16}	Heptane	− 9.21	(127)
C_7H_{16}	*Heptane*	− 1.63	(127)
$C_9H_8O_2$	*Cinnamic acid* (13°)	−15.9	(126)
$C_{10}H_8$	*Naphthalene*	−20.5	(122, 127)
$C_{12}H_{10}$	*Acenaphthene* (13°)	−28.50	(122)
$C_{12}H_{24}O_2$	*Lauric acid*	−40.2	(127)

* The numbers not in parentheses are numbers of other tables in this section which should be consulted for further data.

TABLE 2.—(*Continued*)

B-Component Formula	B-Component Name (and temp., °C)	Q	Lit. and Table No.*
	$C_4H_5Cl_3O_2$, Ethyl trichloroacetate		
$C_4H_8O_2$	*Ethyl acetate*		3
	$C_4H_8O_2$, Ethyl acetate		
$C_4H_{10}O$	*Ethyl ether*		3, 4
$C_4H_{10}O$	Isobutyl alcohol	− 6.70	(127); 3
C_5H_5N	Pyridine	− 0.25	(127)
$C_5H_{12}O$	Isoamyl alcohol		3
$C_6H_4N_2O_4$	*m-Dinitrobenzene*	14.790	(56)
C_6H_6	Benzene	− 0.67	(127); 3
C_6H_6	*Benzene*	− 0.59	(127); 4
$C_6H_6O_2$	*Resorcinol*	1.3	(127)
C_6H_7N	*Aniline*	3.01	(127)
$C_6H_{12}O_2$	Amyl formate		3
$C_7H_5NO_4$	*o-Nitrobenzoic acid*	−13.4	(127)
$C_7H_6O_2$	*Benzoic acid*	−13.0	(127)
$C_7H_6O_3$	*Salicylic acid*	− 8.37	(127)
$C_7H_6O_3$	*m-Hydroxybenzoic acid*	− 7.95	(127)
$C_7H_9NO_2$	*Pyridine acetate*	− 0.988	(109)
$C_7H_{14}O_2$	Amyl acetate		3, 4
C_7H_{16}	Heptane	− 5.06	(127)
C_7H_{16}	*Heptane*	− 5.61	(127)
$C_9H_{10}O_2$	Ethyl benzoate		3
$C_{10}H_8$	*Naphthalene*	−17.2	(127)
$C_{12}H_{24}O_2$	*Lauric acid*	−41.0	(127)
$C_{22}H_{42}O_2$	*Erucic acid*	−56.5	(127)
	C_4H_9Cl, Isobutyl chloride		
C_5H_5N	*Pyridine*	1.3	(127)
C_6H_6	*Benzene*	− 0.96	(127)
C_7H_{16}	*Heptane*	− 2.01	(127)
	$C_4H_{10}O$, Ethyl ether		
$C_4H_{10}O$	*Isobutyl alcohol*		3
C_5H_5N	Pyridine	− 0.84	(127)
$C_5H_{12}O$	Isoamyl alcohol		3
$C_6H_4N_2O_4$	*m-Dinitrobenzene*	−22.64	(88)
$C_6H_5NO_3$	*o-Nitrophenol*	−17.6	(88)
C_6H_6	Benzene	− 0.42	(127); 4
C_6H_6O	*Phenol*	− 0.36	(88)
$C_6H_6O_3$	*Pyrogallol*	− 1.7	(88)
C_6H_7N	*Aniline*		3
$C_6H_{12}O_3$	*Paraldehyde*		3
$C_7H_6O_2$	*Benzoic acid*	−10.0	(127)
$C_{10}H_7NO_2$	*Nitronaphthalene*	−24.20	(88)
$C_{10}H_8$	*Naphthalene*	−20.30	(88)
$C_{10}H_{14}O$	*Thymol*	− 4.48	(88)
$C_{10}H_{20}O$	*Menthol*	−19.29	(88)
$C_{12}H_{10}N_2$	*Azobenzene*	−20.67	(88)
$C_{12}H_{11}N$	*Diphenylamine*	−14.6	(88)
	$C_4H_{10}O$, Isobutyl alcohol		
$C_5H_{12}O$	*Isoamyl alcohol*		3
C_6H_6	*Benzene*	− 3.18	(127)
C_7H_{16}	*Heptane*	− 1.7	(127)
	C_5H_5N, Pyridine		
C_6H_5ClO	*o*-Chlorophenol		4
$C_6H_5NO_3$	*o-Nitrophenol*	−10.0	(127)
C_6H_6	*Benzene*	0	(127)
C_6H_6O	*Phenol*	7.11	(127)
$C_6H_6O_2$	*Resorcinol*	20.9	(127)
C_7H_8O	*o-Cresol*		4
C_7H_8O	*m-Cresol*		4

TABLE 2.—(*Continued*)

B-Component Formula	B-Component Name (and temp., °C)	Q	Lit. and Table No.*
	$C_5H_{10}O_2$, Propyl acetate		
$C_6H_{12}O_2$	*Amyl formate*		3
	$C_5H_{12}O$, Amyl alcohol		
C_8H_{10}	*p-Xylene*		4
	$C_5H_{12}O$, Isoamyl alcohol		
C_6H_6	*Benzene*	− 2.9	(127)
C_7H_{16}	*Heptane*	− 1.3	(127)
	$C_6H_4N_2O_4$, *m*-Dinitrobenzene		
C_6H_6	Benzene	−15.86	(88)
	C_6H_5Br, Bromobenzene		
C_6H_5Cl	Chlorobenzene		3
C_6H_6	Benzene		3
	C_6H_5Cl, Chlorobenzene		
C_6H_6	Benzene		(121)
C_8H_{10}	*p-Xylene*		3
	C_6H_5ClO, *o*-Chlorophenol		
$C_8H_{11}N$	*Dimethylaniline*		4
C_9H_7N	Quinoline		4
	$C_6H_5NO_2$, Nitrobenzene		
C_6H_7N	*Aniline*		3
C_7H_9N	*o*-Toluidine		3
$C_8H_{11}N$	Dimethylaniline		3
$C_8H_{11}N$	*Ethylaniline*		3
$C_{10}H_{15}N$	Diethylaniline		3
	$C_6H_5NO_3$, *o*-Nitrophenol		
C_6H_6	Benzene	−20.9	(88, 127)
$C_7H_{14}O_2$	Isoamyl acetate	−14.73	(88)
	C_6H_6, Benzene		
C_6H_6O	*Phenol*	−18.41	(88, 127)
$C_6H_6O_2$	*Resorcinol*	−15.78	(88)
C_6H_7N	Aniline	− 2.51	(127)
C_6H_7N	*Aniline*	− 4.85	(127)
C_6H_{12}	Cyclohexane		3
C_6H_{14}	*n-Hexane*		3
$C_7H_6O_2$	*Benzoic acid*	−14.2	(127)
$C_7H_6O_3$	*Salicylic acid*	−23.9	(127)
C_7H_8	Toluene		3, 4
C_7H_8O	*m-Cresol*		3
$C_7H_9NO_2$	*Pyridine acetate*	− 0.866	(109)
C_7H_{16}	Heptane	− 2.89	(127)
C_7H_{16}	*Heptane*	− 4.39	(127)
C_8H_{10}	*m*-Xylene		3
C_8H_{18}	Octane	− 2.9	(127)
$C_{10}H_7NO_2$	*Nitronaphthalene*	−22.52	(88)
$C_{10}H_8$	*Naphthalene*	−18.50	(88, 127)
$C_{10}H_{14}O$	*Thymol*	−23.8	(88, 127)
$C_{10}H_{16}$	*Pinene*		3
$C_{10}H_{20}O$	*Menthol*	−28.0	(88)
$C_{12}H_{10}$	*Diphenyl*	−18.0	(88)
$C_{12}H_{10}N_2$	*Azobenzene*	−21.18	(88)
$C_{12}H_{11}N$	*Diphenylamine*	−16.99	(88)
$C_{12}H_{24}O_2$	*Lauric acid*	−40.6	(127)
$C_{14}H_{28}O_2$	*Myristic acid*	−50.2	(127)
$C_{16}H_{32}O_2$	*Palmitic acid*	−59.0	(127)
$C_{19}H_{16}$	*Triphenylmethane*	−17.6	(127)
$C_{22}H_{42}O_2$	*Erucic acid*	−56.5	(127)

* The numbers not in parentheses are numbers of other tables in this section which should be consulted for further data.

TABLE 2.—(*Continued*)

B-Component Formula	B-Component Name (and temp., °C)	Q	Lit. and Table No.*
	C_6H_6O, Phenol		
C_6H_7N	Aniline		(103)
	$C_6H_6O_3$, Pyrogallol		
C_6H_7N	Aniline	11.51	(88)
$C_7H_{14}O_2$	Amyl acetate	0	(88)
	C_6H_7N, Aniline		
C_6H_{14}	*Hexane*		(99)
C_7H_{16}	*Heptane*	−10.17	(127)
C_8H_{10}	*p-Xylene*		4
$C_{10}H_7NO_2$	*Nitronaphthalene*	−17.54	(88)
$C_{10}H_8$	*Naphthalene*	−19.80	(88)
	C_6H_{12}, Cyclohexane		
C_6H_{14}	*n-Hexane*		3
C_7H_8	Toluene		3
C_8H_{10}	*p*-Xylene		3
	$C_7H_6O_2$, Benzoic acid		
C_7H_8	Toluene	−14.2	(127)
	C_7H_8, Toluene		
C_7H_8O	*m*-Cresol		3
C_7H_{16}	*Heptane*	− 2.26	(127)
C_8H_{10}	*p*-Xylene		3
$C_{10}H_8$	*Naphthalene* (23°)	−17.87	(122)
$C_{12}H_{10}$	*Acenaphthene*(23°)	−20.05	(122)
$C_{12}H_{24}O_2$	*Lauric acid*	−38.1	(127)
$C_{19}H_{16}$	*Triphenylmethane*	−17.2	(127)
	C_7H_8O, *m*-Cresol		
C_7H_9N	*o*-Toluidine		3
$C_8H_{11}N$	Dimethylaniline		3
	$C_7H_{14}O_2$, Amyl acetate		
$C_{10}H_7NO_2$	*Nitronaphthalene*	−18.75	(88)
$C_{12}H_{10}N_2$	*Azobenzene*	−20.67	(88)
$C_{12}H_{11}N$	*Diphenylamine*	−14.86	(88)
	C_8H_{10}, *o*-Xylene		
C_8H_{10}	*m*-Xylene		3
C_8H_{10}	*p-Xylene*		3
	C_8H_{10}, *m*-Xylene		
C_8H_{10}	*p*-Xylene		3
$C_8H_{11}N$	Dimethylaniline		3

TABLE 3

The concentration is expressed by x_A, the mole fraction of the A-component in the mixture. Q is expressed in kilojoules evolved per mole mixture. The temperature is between 15 and 20° unless otherwise indicated.

H_2O

B = C_2H_6O (51)

Ethyl alcohol

x_A, t	Q
0.640 | 77°	−0.078
0.843 | 79.2°	+0.159

B = $C_2H_6O_2$ (119)

Glycol

x_A	Q
t = 17°	
0.1	0.175
0.2	0.349
0.3	0.423

B = $C_2H_6O_2$.— (*Continued*)

x_A	Q
0.4	0.6349
0.5	0.7286
0.6	0.7713
0.7	0.7433
0.8	0.7110
0.9	0.519
t = 32°	
0.1	0.147
0.2	0.295
0.3	0.357

B = $C_2H_6O_2$.— (*Continued*)

x_A	Q
0.4	0.5311
0.5	0.6148
0.6	0.6696
0.7	0.6725
0.8	0.6457
0.9	0.429
t = 55°	
0.1	0.136
0.2	0.271
0.3	0.328

B = $C_2H_6O_2$.—(*Continued*)

x_A	Q
0.4	0.4838
0.5	0.5574
0.6	0.6056
0.7	0.6211
0.8	0.5867
0.9	0.397
t = 76°	
0.1	0.136
0.2	0.271
0.3	0.329
0.4	0.4708
0.5	0.5311
0.6	0.5604
0.7	0.5796
0.8	0.5679
0.9	0.371

CCl_4

B = CS_2 (94.1)

t = 25°

0.0934	−0.127
0.1425	−0.180
0.2838	−0.276
0.4001	−0.307
0.5393	−0.311
0.6693	−0.264
0.8153	−0.179

B = $CHCl_3$ (94.1)

t = 25°

0.1150	−0.103
0.2428	−0.176
0.3623	−0.219
0.4331	−0.228
0.5411	−0.226
0.7295	−0.185
0.8178	−0.146

B = $C_2H_4Br_2$ (94.1)

Ethylene bromide

t = 25°

0.1146	−0.198
0.2817	−0.406
0.3733	−0.472
0.4835	−0.509
0.5404	−0.511
0.7565	−0.414
0.8455	−0.274

B = $C_4H_8O_2$ (51)

Ethyl acetate

t = 74.8°

0.308	−0.259

B = C_6H_6 (94.1)

t = 25°

0.2996	−0.091
0.3506	−0.106
0.5012	−0.107
0.6177	−0.104
0.7309	−0.089
0.8675	−0.054
(5)	
0.033	−0.013
0.256	−0.086

B = C_6H_6.—(*Cont'd*)

x_A	Q
0.443	−0.110
0.507	−0.111
0.538	−0.106
0.636	−0.098
0.764	−0.072

B = C_6H_7N (94)

Aniline

t = 25°

0.0942	−0.408
0.1848	−0.707
0.3005	−0.991
0.4152	−1.181
0.4827	−1.218
0.5504	−1.245
0.6215	−1.209
0.7175	−1.129
0.7888	−1.030
0.8627	−0.787
0.9092	−0.623

B = C_7H_8 (5)

Toluene

0.216	0.0150
0.327	0.0193
0.475	0.2578

CS_2

B = $CHCl_3$ (94.1)

t = 25°

0.1897	−0.313
0.3492	−0.474
0.4046	−0.513
0.5906	−0.534
0.6720	−0.502
0.8193	−0.352
0.9351	−0.143

B = $C_2H_4Br_2$ (94.1)

Ethylene bromide

t = 25°

0.1607	−0.378
0.3728	−0.693
0.5184	−0.788
0.5683	−0.792
0.8300	−0.521
0.9206	−0.280

B = $C_4H_8O_2$ (94.1)

Ethyl acetate

t = 25°

0.2199	−0.729
0.4690	−1.123
0.5249	−1.145
0.6522	−1.112
0.7578	−0.946
0.8119	−0.821
0.9130	−0.468

B = $C_4H_{10}O$ (94.1)

Ethyl ether

t = 25°

0.1462	−0.200
0.3571	−0.396
0.4167	−0.436
0.6014	−0.456

B = $C_4H_{10}O$.—(*Continued*)

x_A	Q
0.7305	−0.397
0.7703	−0.358
0.9246	−0.157

B = C_6H_6 (94.1, 118)

t = 25°

0.2020	−0.338
0.5224	−0.565
0.6229	−0.541
0.7259	−0.465
0.8384	−0.339
0.9025	−0.227

B = $C_6H_{12}O_2$ (94.1)

Paraldehyde

t = 25°

0.2974	−0.959
0.3908	−1.126
0.5498	−1.268
0.6365	−1.250
0.6972	−1.193
0.8243	−0.916
0.9082	−0.580

B = $C_{10}H_{16}$ (94.1)

Pinene

t = 25°

0.2845	−0.264
0.4719	−0.367
0.6532	−0.379
0.7353	−0.353
0.7976	−0.318
0.8998	−0.200
0.9585	−0.095

$CHBr_3$

B = C_7H_8 (5)

Toluene

0.067	0.082
0.238	0.248
0.444	0.326
0.780	0.223
0.940	0.075

$CHCl_3$

B = CH_4O (94.1)

Methyl alcohol

t = 25°

0.1154	0.434
0.2041	0.594
0.3001	0.607
0.4715	+0.349
0.6345	−0.014
0.6645	−0.080
0.8042	−0.314
0.9141	−0.393

B = $C_2H_4Br_2$ (94.1)

Ethylene bromide

t = 25°

0.2991	0.087
0.4246	0.103
0.5352	0.109
0.6293	0.108
0.8476	0.048
0.8902	0.030

B = C_2H_4O (94.1)

Acetaldehyde

t = 25°

0.2125	0.652
0.2562	0.782
0.3833	1.058
0.4144	1.109
0.4348	1.121
0.5787	1.208
0.6759	1.133
0.7226	1.076

B = C_2H_6O (94.1)

Ethyl alcohol

t = 25°

0.1216	0.508
0.1765	0.644
0.3175	0.624
0.3777	0.489
0.4770	0.246
0.5716	+0.009
0.7470	−0.365
0.8350	−0.457
0.9412	−0.387

B = C_3H_6O (51)

Acetone

x_A, t		Q
0.262	57°	1.214
0.359	59°	1.569
0.614	62°	1.544

x_A	Q
t = 25° (94.1)	
0.2481	1.167
0.3967	1.715
0.4578	1.868
0.5004	1.921
0.5476	1.973
0.6486	1.900
0.6981	1.775
0.7558	1.573
0.9808	0.159

B = C_3H_8O (94.1)

n-Propyl alcohol

t = 25°

0.0486	0.212
0.1640	0.415
0.2794	0.342
0.3399	+0.244
0.5011	−0.131
0.5123	−0.151
0.6823	−0.516
0.7411	−0.587
0.8347	−0.637
0.9359	−0.449

B = $C_4H_8O_2$ (94.1)

Ethyl acetate

t = 25°

0.2145	1.109
0.3766	1.748
0.4581	1.967
0.5850	2.034
0.6255	1.985
0.6955	1.841
0.7158	1.778
0.9102	0.721

B = $C_4H_{10}O$ (94.1)

Ethyl ether

x_A	Q
t = 25°	
0.1819	1.445
0.3627	2.405
0.4805	2.701
0.5031	2.708
0.5243	2.714
0.5841	2.599
0.6563	2.402
0.7516	1.915

B = $C_4H_{10}O$ (94.1)

Isobutyl alcohol

t = 25°

0.0586	0.080
0.0822	+0.089
0.1980	−0.015
0.2804	−0.214
0.5146	−0.743
0.6103	−0.873
0.8225	−0.882
0.9502	−0.455

B = $C_5H_{12}O$ (94.1)

Isoamyl alcohol

t = 25°

0.0129	0.102
0.0789	0.157
0.1972	+0.144
0.3742	−0.139
0.4590	−0.336
0.5793	−0.556
0.7986	−0.752
0.9402	−0.483

B = C_6H_5Cl (5)

0.204	0.102
0.339	0.149
0.4344	0.168
0.561	0.1753

B = C_6H_6 (5)

0.067	0.063
0.230	0.193
0.340	0.268
0.584	0.360
0.737	0.306
0.850	0.201
t = 25° (94.1)	
0.1461	0.197
0.3115	0.324
0.4584	0.401
0.5601	0.424
0.7572	0.369
0.8681	0.239

B = C_6H_{10} (5)

Cyclohexene

0.100	0.0410
0.290	0.0891
0.525	0.1096

B = C_6H_{12} (5)

Cyclohexane

0.255	−0.5102
0.410	−0.6424
0.578	−0.6278
0.696	−0.5487
0.873	−0.2942

B = $C_6H_{12}O_3$ (94.1)

Paraldehyde

x_A	Q
t = 25°	
0.2406	1.349
0.3982	1.988
0.4981	2.231
0.5916	2.311
0.6996	2.142
0.8519	1.373
0.9428	0.611

B = C_7H_8 (5)

Toluene

0.075	0.184
0.260	0.5374

B = C_8H_{10} (5)

p-Xylene

0.097	0.285
0.298	0.720
0.425	0.875
0.490	0.912
0.772	0.672
0.856	0.473

CH_2O_2

Formic acid

B = $C_2H_4O_2$ (101, 104)

Acetic acid

0.50	0.303

CH_4O

Methyl alcohol

B = C_2H_6O (94.1)

Ethyl alcohol

t = 25°

0.4421	−0.003
0.6110	−0.008
0.7082	−0.009

B = C_3H_6O (94.1)

Acetone

t = 25°

0.2426	−0.541
0.4244	−0.686
0.5163	−0.671
0.5966	−0.635
0.6014	−0.632
0.6870	−0.556
0.8067	−0.387
0.9315	−0.149

B = C_3H_8O (94.1)

n-Propyl alcohol

t = 25°

0.4451	−0.091
0.6666	−0.097
0.7962	−0.074

B = C_3H_8O (101, 104)

Isopropyl alcohol

x_A, t		Q
0.25	14.6°	0.082
0.25	34.2°	0.073
0.50	15.2°	0.080
0.50	30°	0.060
0.75	16.3°	0.051
0.75	34.1°	0.040

CH_4O.—(*Cont'd*)

B = $C_4H_{10}O$ (94.1)
Ethyl ether

x_A	Q
t = 25°	
0.2173	−0.414
0.3197	−0.502
0.5582	−0.410
0.6386	−0.336
0.7101	−0.257
0.8221	−0.153
0.9259	−0.049

B = $C_4H_{10}O$ (94.1)
Isobutyl alcohol

t = 25°	
0.5140	−0.170
0.7135	−0.165
0.8508	−0.116

B = $C_5H_{12}O$ (94.1)
Isoamyl alcohol

t = 25°	
0.5140	−0.191
0.7683	−0.187
0.8684	−0.132

B = C_6H_7N (94)
Aniline

t = 25°	
0.0855	−0.018
0.1639	−0.016
0.2558	+0.015
0.3297	0.053
0.4359	0.116
0.5261	0.149
0.6205	0.187
0.7228	0.215
0.8172	0.208
0.8397	0.200
0.9362	0.121
0.9486	0.094

$C_2H_4Br_2$

Ethylene bromide
B = $C_2H_4Cl_2$ (5)
Ethylene chloride

0.215	−0.123

B = C_6H_5Cl (5)
Chlorobenzene

0.070	−0.086
0.332	−0.286

B = C_6H_6 (5)

0.054	−0.0590
0.186	−0.1762
0.364	−0.2624
0.535	−0.2888
0.648	−0.2616
0.821	−0.1728
0.946	−0.0590

B = C_6H_{10} (5)
Cyclohexene

0.107	−0.2440
0.296	−0.0544

B = C_6H_{12} (5)
Cyclohexane

0.098	−0.490
0.182	−0.841

B = C_6H_{12}.—(*Continued*)

x_A	Q
0.308	−1.184
0.375	−1.297
0.495	−1.381
0.529	−1.364
0.555	−1.360
0.687	−1.168
0.690	−1.168
0.765	−0.992
0.842	−0.741
0.949	−0.2745

B = C_6H_{14} (5)
n-Hexane

0.94	−0.4009

B = C_7H_8 (5)
Toluene

0.078	+0.0732
0.250	−0.0121
0.450	−0.0691
0.567	−0.0975
0.710	−0.114
0.830	−0.109

B = C_8H_{10} (5)
p-Xylene

0.082	0.087
0.272	0.175
0.486	0.106
0.602	0.036
0.642	+0.010
0.722	−0.036
0.868	−0.0632
0.966	−0.029

B = C_9H_{12} (5)
Mesitylene

0.110	0.0737
0.350	+0.0360
0.486	−0.0636
0.638	−0.1331
0.749	−0.1632
0.878	−0.1163

B = $C_{10}H_{14}$ (5)
p-Cymene

0.100	−0.00862
0.320	−0.0866
0.454	−0.1787
0.610	−0.2611
0.804	−0.297
0.900	−0.2335

$C_2H_4Cl_2$

Ethylene chloride
B = C_6H_6 (5)

0.74	−0.0732

B = C_7H_8 (5)
Toluene

0.079	0.0427
0.262	0.0783
0.385	0.661
0.537	0.025
0.618	+0.0025
0.803	−0.0314
0.944	−0.0184

C_2H_4O

Acetaldehyde
B = C_2H_6O (104.1)
Ethyl alcohol

x_A	Q
0.1621	−1.530
0.2475	−2.750
0.2709	−2.979
0.2910	−3.300
0.3059	−3.269
0.3422	−3.756
0.3906	−3.974
0.4211	−4.131
0.4244	−4.104
0.4422	−4.177
0.4973	−4.188
0.5114	−4.029
0.5285	−3.599
0.5470	−3.085
0.5812	−2.826
0.6478	−2.321
0.6717	−2.160
0.8110	−1.658

B = $C_4H_{10}O$ (94.1)
Ethyl ether

t = 25°	
0.3477	−0.523
0.5434	−0.565
0.6588	−0.515
0.7473	−0.428
0.8740	−0.250

$C_2H_4O_2$

Acetic acid
B = $C_3H_6O_3$ (104)
Lactic acid

0.5	0.258

B = $C_4H_8O_2$ (104)
Isobutyric acid

0.49	0.206

B = C_6H_6 (4)

t = 5.3°	
0.1528	−0.064
0.1765	−0.083
0.2120	−0.126
0.2500	−0.197
0.3289	−0.301

B = C_6H_{12} (5)
Cyclohexane

0.2424	−1.2743
0.417	−1.5945
0.540	−1.4145
0.643	−1.5246
0.701	−1.4380
0.772	−1.197
0.825	−0.983

B = C_7H_8 (5)
Toluene

0.189	−0.2256
0.258	−0.2754
0.324	−0.3281
0.437	−0.368
0.482	−0.3729
0.537	−0.3720

C_2H_6O

Ethyl alcohol
B = C_3H_6O (94.1)
Acetone

x_A	Q
t = 25°	
0.1710	−0.705
0.3404	−1.055
0.4417	−1.123
0.5400	−1.117
0.5558	−1.117
0.6325	−1.050
0.7392	−0.879
0.8947	−0.444

B = C_3H_8O
n-Propyl alcohol

t = 25° (94.1)	
0.3541	−0.023
0.6031	−0.027
0.8030	−0.021
t = 25° (113)	
0.158	−0.013
0.303	−0.018
0.439	−0.020
0.566	−0.020
0.684	−0.017
0.796	−0.012
0.902	−0.007

B = $C_4H_8O_2$ (94.1)
Ethyl acetate

t = 25°	
0.1932	−0.934
0.5346	−1.320
0.5445	−1.166?
0.5812	−1.216?
0.7077	−1.045
0.7776	−0.846
0.9051	−0.421

B = $C_4H_{10}O$ (94.1)
Ethyl ether

t = 25°	
0.0882	−0.382
0.2756	−0.668
0.4379	−0.677
0.5889	−0.569
0.6675	−0.478
0.7191	−0.434
0.8380	−0.254
0.9695	−0.040

B = $C_4H_{10}O$ (94.1)
Isobutyl alcohol

t = 25°	
0.3519	−0.050
0.5914	−0.064
0.7748	−0.046

B = $C_5H_{12}O$ (94.1)
Isoamyl alcohol

t = 25°	
0.3440	−0.057
0.6977	−0.067
0.8302	−0.058

B = C_6H_6 (51)

x_A, t		Q
0.420	68.2°	−0.963
0.649	68.5°	−1.507
0.807	68.9°	−0.812

C_3H_6O

Acetone
B = $C_4H_8O_2$ (94.1)
Ethyl acetate

x_A	Q
t = 25°	
0.2062	−0.093
0.3237	−0.120
0.5046	−0.133
0.5965	−0.131
0.6644	−0.123
0.7535	−0.098
0.9128	−0.045

B = $C_4H_{10}O$
Ethyl ether

t = 25° (94.1, 117)	
0.1155	0.249
0.2068	0.385
0.2943	0.461
0.4998	0.505
0.7270	0.385
0.8295	0.258
0.9077	0.159

x_A, t		Q (51)
0.334	37.1°	−0.473
0.456	40°	−0.404
0.594	40.5°	−0.557
0.789	46.3°	−0.312

$C_3H_6O_2$

Methyl acetate
B = $C_4H_8O_2$
Ethyl acetate (101, 104)

x_A	Q
0.50	0.052

C_3H_8O

n-Propyl alcohol
B = $C_4H_8O_2$ (94.1)
Ethyl acetate

t = 25°	
0.1382	−0.852
0.2784	−1.318
0.4406	−1.521
0.4779	−1.523
0.4875	−1.511
0.6248	−1.406
0.7880	−0.990
0.9101	−0.509

B = $C_4H_{10}O$ (94.1)
Ethyl ether

t = 25°	
0.1056	−0.431
0.2110	−0.637
0.4258	−0.732
0.5322	−0.685
0.5548	−0.662
0.6949	−0.518
0.8135	−0.327
0.9311	−0.129

B = $C_4H_{10}O$ (94.1)
Isobutyl alcohol

t = 25°	
0.3242	−0.005
0.5943	−0.008
0.7167	−0.009

B = $C_5H_{12}O$ (94.1)
Isoamyl alcohol

x_A	Q
t = 25°	
0.4247	−0.002
0.6166	−0.008
0.8204	−0.005

B = C_6H_7N (104)
Aniline

0.35	0.791
0.80	0.481

$C_4H_5Cl_3O_2$

Ethyl trichloro-acetate
B = $C_4H_8O_2$
Ethyl acetate (101, 104)

x_A, t		Q
0.25	16.7°	−0.144
0.25	34.1°	−0.100
0.50	15.9°	−0.176
0.50	34.2°	−0.130
0.75	16.5°	−0.156
0.75	33.5°	−0.089

$C_4H_8O_2$

Ethyl acetate
B = $C_4H_{10}O$ (94.1)
Ethyl ether

x_A	Q
t = 25°	
0.0875	−0.091
0.2269	−0.200
0.4372	−0.255
0.4560	−0.256
0.4803	−0.256
0.5815	−0.251
0.7256	−0.200
0.8419	−0.139

B = $C_4H_{10}O$ (94.1)
Isobutyl alcohol

t = 25°	
0.0979	−0.655
0.2968	−1.518
0.3678	−1.687
0.5444	−1.810
0.5846	−1.772
0.7146	−1.572
0.8564	−0.958

B = $C_5H_{12}O$ (94.1)
Isoamyl alcohol

t = 25°	
0.1824	−1.053
0.2358	−1.353?
0.4192	−1.748
0.5701	−1.739
0.5912	−1.718
0.6260	−1.684
0.7666	−1.355
0.8931	−0.776

B = C_6H_6 (94.1)

t = 25°	
0.0943	−0.033
0.2479	−0.062
0.3694	−0.091
0.5065	−0.098

B = C_6H_6.—(*Continued*)

x_A	Q
0.6324	−0.094
0.7976	−0.075
0.8760	−0.040

B = $C_6H_{12}O_2$ (101, 104)
Amyl formate

0.50	0.036

B = $C_7H_{14}O_2$ (101, 104)
Amyl acetate

0.49	0.216

B = $C_9H_{10}O_2$ (101, 104)
Ethyl benzoate

0.50	−0.227

$C_4H_{10}O$
Ethyl ether
B = $C_4H_{10}O$ (94.1)
Isobutyl alcohol
t = 25°

0.1097	−0.266
0.2467	−0.552
0.3654	−0.732
0.4813	−0.839
0.5449	−0.867
0.6828	−0.836
0.8614	−0.549
0.9478	−0.252

B = $C_5H_{12}O$ (94.1)
Isoamyl alcohol
t = 25°

0.1245	−0.271
0.3187	−0.592
0.4137	−0.699
0.5539	−0.770
0.5705	−0.776
0.7034	−0.739
0.8132	−0.603
0.8825	−0.465

B = C_6H_7N (94)
Aniline
t = 20°

0.1031	0.129
0.1933	0.206
0.3060	0.338
0.3833	0.406
0.4947	0.498
0.5961	0.542
0.6802	0.538
0.7927	0.461
0.8579	0.354
0.9294	0.225

B = $C_6H_{12}O_3$ (94.1)
Paraldehyde
t = 25°

0.2360	−0.210
0.4174	−0.299
0.5545	−0.314
0.5958	−0.315
0.6546	−0.300
0.7694	−0.244
0.9077	−0.132

$C_4H_{10}O$
Isobutyl alcohol
B = $C_5H_{12}O$ (94.1)
Isoamyl alcohol

x_A	Q
t = 25°	
0.3349	−0.005
0.5251	−0.006
0.7520	−0.015

$C_5H_{10}O_2$
Propyl acetate
B = $C_6H_{12}O_2$ (101, 104)
Amyl formate

0.299	−0.003
0.742	−0.013

C_6H_5Br
Bromobenzene
B = C_6H_5Cl (101, 104)
Chlorobenzene

0.212	0.0121
0.674	0.0154

B = C_6H_6 (5)

0.255	−0.038

C_6H_5Cl
Chlorobenzene
B = C_8H_{10} (5)
p-Xylene

0.198	0.080
0.330	0.106
0.425	0.116
0.790	0.076
0.939	0.028

$C_6H_5NO_2$
Nitrobenzene
B = C_6H_7N (101, 104)
Aniline

x_A, t		Q
0.25	87.6°	0.306
0.25	51.6°	0.322
0.25	16.5°	0.519
0.50	86.39°	0.343
0.50	52.16°	0.452
0.50	14°	0.552
0.75	86.3°	0.318
0.75	15°	0.398

B = C_7H_9N (101, 104)
o-Toluidine

0.50	17.6°	0.243
0.50	14.2°	0.239

B = $C_8H_{11}N$ (101, 104)
Dimethylaniline

x_A	Q
t = 15°	
0.46	−0.031

B = $C_8H_{11}N$ (101, 104)
Ethylaniline

0.51	0.112

B = $C_{10}H_{15}N$ (101, 104)
Diethylaniline

0.50	−0.062

C_6H_6
B = C_6H_{12} (5)
Cyclohexane

x_A	Q
0.097	−0.3013
0.670	−0.7140
0.752	−0.6068
0.859	−0.4028
0.924	−0.2323

B = C_6H_{14} (5)
n-Hexane

0.579	−0.912
0.687	−0.841
0.844	−0.5177
0.940	−0.2172

B = C_7H_8 (5)
Toluene

0.324	−0.0619
0.490	−0.0753
0.500	−0.0791*
0.600	−0.0703
0.750	−0.0561
0.857	−0.0360

* (101, 104).

B = C_7H_8O (101, 102, 104)
m-Cresol

0.54	0.866

B = C_8H_{10} (101, 104)
m-Xylene

0.5	0.239

B = $C_{10}H_{16}$ (94.1)
Pinene
t = 25°

0.2128	−0.424
0.4758	−0.739
0.5399	−0.730
0.6251	−0.725
0.7634	−0.624
0.8686	−0.470
0.9382	−0.234

C_6H_{12}
Cyclohexane
B = C_6H_{14} (5)
n-Hexane

0.75	−0.2000

B = C_7H_8 (5)
Toluene

0.053	−0.1247
0.165	−0.3465
0.324	−0.561
0.671	−0.586
0.743	−0.5114
0.832	−0.3926
0.946	−0.1448

B = C_8H_{10} (5)
p-Xylene

0.077	−0.1461
0.185	−0.3139
0.329	−0.4604
0.460	−0.5265
0.5114	−0.5432
0.5753	−0.5457
0.657	−0.5189

B = C_8H_{10}.—(*Continued*)

x_A	Q
0.767	−0.4369
0.920	−0.1954

C_7H_8
Toluene
B = C_7H_8O
m-Cresol (101, 104)

0.47	0.686

B = C_8H_{10} (5)
p-Xylene

0.232	−0.00565
0.350	−0.0084
0.480	−0.0092

C_7H_8O
m-Cresol (101, 104)
B = C_7H_9N
o-Toluidine

B = C_7H_9N.—(*Continued*)

x_A, t		Q
0.25	20.4°	−1.590
0.25	88°	−1.193
0.50	22.1°	−2.469
0.50	55.9°	−2.072
0.50	90.5°	−1.988
0.75	19.4°	−2.406
0.75	54.6°	−1.871
0.75	90°	−1.716

B = $C_8H_{11}N$
Dimethylaniline

0.50	16.3°	−0.144
0.50	15.3°	−0.128

C_8H_{10}
o-Xylene (101, 104)
B = C_8H_{10}
m-Xylene

B = C_8H_{10}.—(*Continued*)

x_A	Q
0.269	0.0092
0.729	0.0067

B = C_8H_{10}
p-Xylene

0.319	0.011
0.815	0.004

C_8H_{10}
m-Xylene (101, 104)
B = C_8H_{10}
p-Xylene

0.292	−0.0109
0.754	−0.0013

B = $C_8H_{11}N$
Dimethylaniline

0.287	0.011
0.734	0.013

TABLE 4

The concentration is expressed as weight per cent of the A-component in the mixture. Q is expressed in joules evolved per gram of mixture.

H_2O
B = C_3H_6O (118.1)
Acetone

% A	Q
t = 15°	
19.04	6.9
29.91	13.5
40.29	22.9
50.00	28.5
55.60	30.4
60.00	31.1
65.00	32.2
66.67	32.0
70.00	31.6
75.00	29.8
81.19	26.5
84.80	21.3
90.00	16.5
95.00	8.4

B = $C_3H_8O_3$
Glycerol
(63)

10	7.5
20	10.9
30	15.5
40	17.6
50	18.8
60	18.8
70	16.3
80	13.4
90	8.0

(98)

15.3	12
25.9	16
37.8	18
55.2	18
64.2	17
75.4	13

B = $C_3H_8O_3$.—(*Continued*)

% A	Q
86.1	8.2
90.2	6.0
92.8	4.6
96.2	2.6

CCl_4
B = C_6H_6 (118.2)
t = 18°

10	−0.301
20	−0.598
30	−0.816
40	−0.963
50	−1.030
60	−1.030
70	−0.912
80	−0.699
90	−0.452

B = C_7H_8 (118.2)
Toluene
t = 17°

10	0.067
20	0.138
30	0.197
40	0.264
50	0.318
60	0.335
70	0.326
80	0.276
90	0.172

CS_2
B = $CHCl_3$ (118.2)
Chloroform
t = 13°

10	−2.55
20	−4.44
30	−5.65

$CHCl_3$.—(*Cont'd*)

% A	Q
40	−6.40
50	−6.65
60	−6.28
70	−5.27
80	−3.89
90	−2.22

B = C_2H_6O (137)
Ethyl alcohol
t = 0°

10	−2.948
20	−5.488
30	−7.483
40	−8.706
50	−9.203
60	−9.010
70	−8.513
80	−6.910
t = 3.2 to 5.5°	
10	−3.01
20	−5.603
30	−7.551
40	−8.844
50	−9.515
60	−9.607
70	−8.844
80	−7.369
t = 15.5°	
10	− 3.229
20	− 5.896
30	− 8.041
40	− 9.296
50	−10.47
60	−10.52
70	− 9.524
80	− 8.658

CS_2.—(*Continued*)

B = C_3H_6O (118.2)
Acetone

% A	Q
t = 16°	
10	− 5.78
20	−11.80
30	−16.45
40	−19.92
50	−20.93
60	−20.80
70	−17.62
80	−16.15
90	−10.80

B = C_6H_6 (137)

t = 0°	
10	−2.117
20	−3.85
30	−5.235
40	−6.305
50	−6.690
70	−6.101
80	−4.860
90	−3.001
t = 4°	
10	−2.109
20	−3.827
30	−5.220
40	−6.257
50	−6.600
70	−6.040
80	−4.847
90	−2.997
t = 14.5°	
10	−2.090
20	−3.807
30	−5.127
40	−6.109
50	−6.468
70	−5.920
80	−4.782
90	−2.976
t = 18° (118.2)	
10	−2.59
20	−4.85
30	−6.78
40	−7.70
50	−7.95
60	−7.83
70	−6.82
80	−5.15
90	−2.93

B = C_7H_8 (118.2)
Toluene

t = 18°	
10	−1.38
20	−2.64
30	−3.52
40	−4.44
50	−4.73
60	−4.60
70	−4.02
80	−3.01
90	−1.72

$CHCl_3$
Chloroform

B = C_3H_6O (118.2)
Acetone

% A	Q
t = 14°	
10	4.77
20	9.83
30	14.31
40	19.38
50	23.27
60	25.53
70	25.07
80	21.55
90	13.56

B = $C_4H_{10}O$ (118.2)
Ethyl ether

t = 14°	
10	7.49
20	13.89
30	18.71
40	23.48
50	26.53
60	25.99
70	23.77
80	18.83
90	10.21

B = C_6H_6 (118.2)

t = 18°	
10	1.13
20	2.01
30	2.64
40	3.10
50	3.31
60	3.31
70	3.18
80	2.89
90	2.05

CH_4O
Methyl alcohol

B = C_2H_6O
Ethyl alcohol

t = 0.3° (48)	
32.17	−0.322
67.83	−0.272
85.87	−0.146
t = 16° (118.2)	
10	0.209
20	0.343
30	0.393
40	0.398
50	0.360
60	0.314
70	0.268
80	0.184
90	0.100
t = 20.8° (48)	
32.3	−0.029
49.6	−0.029

B = C_3H_8O
n-Propyl alcohol

t = 0.3° (48)	
32.84	−2.059
47.44	−2.239
70.84	−1.892

B = C_3H_8O.—(*Continued*)

% A	Q
t = 14° (118.2)	
10	−0.75
20	−1.46
30	−2.05
40	−2.34
50	−2.30
60	−2.05
70	−1.72
80	−1.26
90	−0.71
t = 21.3° (48)	
25.56	−1.507
50.03	−2.101
67.46	−1.908
82.41	−1.427

B = C_6H_6 (118.2)

t = 15°	
10	− 9.33
20	− 9.54
30	−10.17
40	− 9.50
50	− 8.29
60	− 6.65
70	− 4.98
80	− 3.35
90	− 1.72

$C_2H_4O_2$
Acetic acid

B = C_6H_6 (118.2)

t = 16°	
10	−2.39
20	−3.68
30	−4.81
40	−5.52
50	−5.98
60	−5.69
70	−5.96
80	−3.93
90	−2.39

C_2H_6O
Ethyl alcohol

B = C_3H_8O (48)
n-Propyl alcohol

t = 0.27°	
45.2	−0.469
62.17	−0.594
t = 21°	
32.86	−0.586
49.58	−0.523

B = C_6H_6 (137)

t = 0°	
10	−4.045
20	−5.253
30	−6.055
40	−6.410
60	−6.120
70	−5.697
80	−4.414
90	−2.550
t = 3.1 to 5.9°	
10	−4.320
20	−5.769

B = C_6H_6.—(*Continued*)

% A	Q
30	−6.550
40	−6.767
60	−6.411
70	−5.812
80	−4.469
90	−2.572
t = 15°	
10	−5.416
20	−6.706
30	−7.338
40	−7.556
60	−6.867
70	−6.067
80	−4.578
90	−2.658

C_3H_6O
Acetone

B = C_6H_5ClO (50)
o-Chlorophenol

t = 0°	
13.90	32.58
17.10	38.00
19.10	40.52
21.90	44.28
23.70	45.70
26.00	47.08
27.55	47.79
29.35	48.55
31.15	48.67
33.80	48.42
37.60	47.63
42.70	45.57
44.05	45.11
50.00	41.93
53.45	39.24
62.00	33.30

$C_3H_6O_2$
Methyl acetate

B = $C_4H_8O_2$ (118.2)
Ethyl acetate

t = 16°	
10	−0.326
20	−0.594
30	−0.757
40	−0.850
50	−0.866
60	−0.787
70	−0.678
80	−0.511
90	−0.293

B = C_6H_6 (118.2)

t = 17°	
10	−2.39
20	−4.52
30	−5.86
40	−6.36
50	−6.32
60	−5.69
70	−4.81
80	−3.64
90	−2.13

C_3H_8O
n-Propyl alcohol

B = C_6H_6 (118.2)

% A	Q
t = 15°	
10	−10.30
20	−12.64
30	−13.56
40	−13.22
50	−12.26
60	−11.09
70	− 8.29
80	− 5.52
90	− 2.76

$C_4H_8O_2$
Ethyl acetate

B = $C_4H_{10}O$ (118.2)
Ethyl ether

t = 14°	
10	−1.09
20	−1.76
30	−2.34
40	−2.76
50	−2.97
60	−2.76
70	−2.43
80	−1.88
90	−1.13

B = C_6H_6 (118.2)

t = 17°	
10	−0.879
20	−1.310
30	−1.465
40	−1.528
50	−1.515
60	−1.444
70	−1.327
80	−1.109
90	−0.682

B = $C_7H_{14}O_2$
Amyl acetate (118.2)

t = 15°	
10	−0.67
20	−1.00
30	−1.55
40	−1.84
50	−1.88
60	−1.76
70	−1.46
80	−1.13
90	−0.67

$C_4H_{10}O$
Ethyl ether

B = C_6H_6 (118.2)

t = 15°	
10–90	0.00

C_5H_5N
Pyridine

B = C_6H_5ClO (50)
o-Chlorophenol

t = 0°	
15.0	63.19
22.0	73.61

B = C_6H_5ClO.—(*Continued*)

% A	Q
25.1	78.01
30.0	85.08
34.0	89.18
38.1	91.15
41.1	90.19
46.9	84.70
55.1	72.74
61.0	63.44

B = C_7H_8O (50)
o-Cresol

t = 0°	
17.5	52.94
25.05	68.63
30.7	76.25
36.4	80.64
39.9	81.11
40.2	81.31
44.85	79.39
48.7	75.79
49.9	74.79
50.85	73.53
57.25	64.74
57.65	64.66
63.0	53.15

B = C_7H_8O (50)
m-Cresol

t = 0°	
9.85	26.03
19.5	45.87
27.5	57.54
33.1	61.60
36.8	63.70
42.2	63.24
49.05	58.97
54.25	54.66
61.00	47.54
68.25	38.54
82.9	21.42

$C_5H_{12}O$
Amyl alcohol

B = C_8H_{10} (55)
p-Xylene

t = 0°	
20.6	4.48
39.2	6.57
46.5	6.78
53.1	6.40
64.8	5.23
72.7	3.81

C_6H_5ClO
o-Chlorophenol

B = $C_8H_{11}N$ (50)
Dimethylaniline

t = 0°	
40.5	20.51
45.7	22.23
49.0	23.30
51.2	23.87
54.2	24.81
57.4	25.80
60.5	26.40
62.6	26.38

B = $C_8H_{11}N$.—(*Continued*)

% A	Q
64.85	25.88
67.25	25.08
69.85	23.87
73.65	22.24
80.0	18.84

B = C_9H_7N (50)
Quinoline

t = 0°	
33.0	56.50
38.8	64.74
43.9	71.98
46.75	74.74
47.9	76.08
50.1	76.46
51.2	76.79

B = C_9H_7N.—(*Continued*)

% A	Q
51.7	76.79
52.6	76.63
53.6	76.33
54.7	75.79
57.5	72.74
61.4	65.83
66.75	57

C_6H_6
B = C_7H_8 (118.2)
Toluene

t = 16°	
10	−0.335
20	−0.603
30	−0.829
40	−0.917

B = C_7H_8.—(*Continued*)

% A	Q
50	−0.933
60	−0.921
70	−0.778
80	−0.519
90	−0.264

C_6H_7N
Aniline
B = C_8H_{10} (55)
p-Xylene

t = 0°	
27.6	9.96
31.7	10.80
49.1	11.22
58	10.42
66	9.54
78.6	6.65

B = $C_2H_4O_2$.—(*Continued*)

M_s	Q
1.47	1.544
2.04	1.803
2.944	2.108
3.67	2.281
4.98	2.486

B = $C_2H_4O_2$ (4)
Acetic acid

0.201	0.498
0.34	0.716
0.273	0.621
0.49	0.883
0.68	1.050
0.943	1.243
1.887	1.594
3.333	1.820

$C_2H_4O_2$
Acetic acid
B = C_6H_6 (4)

0.2143	−0.370
0.2500	−0.414

B = C_6H_6.—(*Cont'd*)

M_s	Q
0.304	−0.481
0.333	−0.514
0.385	−0.552
0.515	−0.661
0.77	−0.820
0.775	−0.824
1.25	−1.004
2.137	−1.251
5.17	−1.515
7.75	−1.569
15.52	−1.689

B = C_6H_6 (4)

0.0644	−0.109
0.129	−0.203
0.1934	−0.293
0.468	−0.586
0.80	−0.804
1.29	−1.063
1.30	−1.063
1.942	−1.282
2.60	−1.434

B = C_6H_6.—(*Continued*)

M_s	Q
3.00	−1.542
3.29	−1.578
4.00	−1.653
4.666	−1.724

C_2H_6O
Ethyl alcohol
B = C_6H_6 (131)

0.2675	−0.289
1.642	−1.548
2.19	−2.093
2.633	−2.427
3.284	−2.930
3.940	−3.390
4.586	−3.850
6.569	−4.637
7.88	−5.608
8.53	−5.859
9.195	−6.236
10.5	−6.738

TABLE 5

The concentration is expressed by the number of moles of solvent, M_s, added to one mole of solute. The B-component where italicized is the solute, and is otherwise the solvent. *Q* is expressed in kilojoules evolved per mole solute.

H_2O
B = CH_2O_2 (64)
Formic acid

M_s	Q
0.135	0.348
0.28	0.744
0.45	1.061
0.85	1.430
1.10	1.460
1.70	1.445
5.96	1.299
48.55	1.257

B = $C_2HBr_3O_2$
Tribromoacetic acid (solid)

t = 15.2° (115)	
206	1.05
417	1.99
799	2.62
∞	3.52

B = $C_2HCl_3O_2$
Trichloroacetic acid (solid)

t = 15.31° (115)	
245	10.48
498	11.32
936	11.29

B = $C_2H_2Br_2O_2$
Dibromoacetic acid (solid)

t = 15.3° (115)	
364	−1.18
479	−3.76
712	−3.42

B = $C_2H_2Cl_2O_2$
Dichloroacetic acid

M_s	Q
t = 15.9° (115)	
196	9.63
398	10.80
776	11.59

B = $C_2H_3BrO_2$
Bromoacetic acid (solid)

t = 15.45° (115)	
199	−13.84
365	−13.45
712	−13.15

B = $C_2H_4O_2$
Acetic acid (64)

0.25	−0.293
0.58	−0.527
1.11	−0.624
1.42	−0.624
1.95	−0.544
5.00	−0.310
6.19	+0.056
30.00	0.386
63.33	0.449
t = 18.5° (115)	
139	1.12
197	1.53*
207	1.15
411	1.37
∞	1.90

* 13.6°.

B = $C_3H_6O_2$ (64)
Propionic acid

M_s	Q
t = 8°	
0.216	−1.40
0.456	−2.00
0.720	−2.29
1.027	−2.46
1.718	−2.62
2.740	−2.52
4.110	−2.35
9.590	−1.79
14.570	−1.48
38.270	−1.26
78.110	−1.25

B = $C_4H_8O_2$ (64)
n-Butyric acid

t = 9°	
0.25	−1.00
0.54	−1.49
0.86	−1.77
1.22	−1.93
1.63	−2.04
2.09	−2.08
3.05	−2.08
3.67	−1.99
7.33	−1.68
19.55	−1.24
44.00	−0.91
93.00	−0.73

$C_2H_4Br_2$
Ethylene bromide
B = $C_2H_4O_2$ (4)
Acetic acid

0.30	0.55
0.528	0.845
1.06	1.318

TABLE 6

The concentration is expressed as the mole per cent of the A-component in the mixture. *Q* is expressed in kilojoules evolved per mole B.

H_2O
B = CH_4O (49)
Methyl alcohol

M % A	Q
t = 0°	
5	0.159
10	0.310
15	0.460
20	0.607
25	0.762
30	0.925
35	1.105
40	1.297
45	1.511
50	1.766
55	2.038
60	2.381
65	2.783
70	3.306
75	3.967
80	4.763
85	5.750
90	6.905
95	8.328
t = 19.69°	
5	0.134
10	0.272
15	0.419
20	0.569
25	0.716
30	0.862
35	1.017
40	1.197
45	1.398

B = CH_4O.—(*Continued*)

M % A	Q
50	1.632
55	1.896
60	2.218
65	2.591
70	3.055
75	3.666
80	4.357
85	5.114
90	5.989
95	6.838
t = 42.37°	
5	0.071
10	0.151
15	0.251
20	0.356
25	0.473
30	0.594
35	0.724
40	0.866
45	1.013
50	1.193
55	1.402
60	1.632
65	1.908
70	2.264
75	2.691
80	3.185
85	3.725
90	4.352
95	4.997

B = C_2H_6O (49)
Ethyl alcohol

M % A	Q
t = 0°	
5	0.088
10	0.176
15	0.289
20	0.410
25	0.498
30	0.590
35	0.691
40	0.824
45	1.004
50	1.251
55	1.523
60	1.900
65	2.385
70	3.038
75	3.972
80	5.428
85	7.407
90	9.856
95	12.54
t = 17.33°	
5	0.042
10	0.092
15	0.167
20	0.251
25	0.335
30	0.423
35	0.519
40	0.636
45	0.757
50	0.946

H_2O.—(*Cont'd*)
B = C_2H_6O.—
(*Continued*)

M % A	Q
55	1.201
60	1.507
65	1.925
70	2.478
75	3.218
80	4.269
85	5.821
90	7.801
95	9.818
t = 42.05°	
5	0.0029
10	0.0063
15	0.013
20	0.023
25	0.042
30	0.075
35	0.109
40	0.167
45	0.243
50	0.343
55	0.465
60	0.649
65	0.870
70	1.209
75	1.691
80	2.356
85	3.281
90	4.528
95	6.236

B = C_3H_8O [49]
n-Propyl alcohol

M % A	Q
t = 0°	
5	−0.011
10	−0.021
15	−0.027
20	−0.019
25	−0.008
30	+0.010
35	0.042
40	0.092
45	0.167
50	0.264
55	0.419
60	0.590
65	0.883
70	1.264
75	1.354
80	2.758
85	4.323
90	7.382
95	12.68
t = 21.03°	
5	−0.042
10	−0.084
15	−0.121
20	−0.159
25	−0.197
30	−0.230
35	−0.243
40	−0.243
45	−0.209
50	−0.167

B = C_3H_8O.—
(*Continued*)

M % A	Q
55	−0.084
60	+0.038
65	0.201
70	0.431
75	0.778
80	1.335
85	2.264
90	4.110
95	7.981
t = 43.44°	
5	−0.105
10	−0.205
15	−0.306
20	−0.402
25	−0.498
30	−0.590
35	−0.670
40	−0.737
45	−0.778
50	−0.795
55	−0.795
60	−0.770
65	−0.728
70	−0.644
75	−0.502
80	−0.259
85	+0.176
90	0.586
95	3.055

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(For a key to the periodicals see end of volume)

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HEAT OF DILUTION

FRANK R. PRATT

INTRODUCTION

If to a solution having an initial concentration C_1 and at the temperature t, °C water at $t°$ is added in sufficient amount to change the concentration to C_2, it is necessary to *abstract* from the system H joules of heat in order to keep its temperature constant, the *amount* of solution being that shown by the quantities in which C_1 is expressed. For example, in the table for KCl below; if to a solution composed of 1 gram-mole of KCl and 25 gram-moles of H_2O, C_1 (=400) at 18°C, 25 gram-moles of H_2O at 18°C be added, the final concentration will be C_2 (=200) and 794 joules of heat must be *supplied* (because of the negative sign) to the resulting mixture in order to maintain it at 18°C. It is the quantity H which (unless otherwise indicated) is recorded below. The values given have been interpolated from the original drawings of the graphs of Pratt, *143*, **185**: 663; 18.

TABLE

Ethyl alcohol (Squibb's), C_1 = 400 = 1M C_2H_5OH and 25M H_2O

t, °C	C_2							
	300	240	200	160	100	80	60	40 | 20
0	309	447	531	602	702	744	782	
5	301	443	523	594	694	732	765	
10	293	435	514	585	686	719	753	*v. further*
15	288	422	506	577	677	711	736	p. 162
20	280	414	493	569	665	694	719	
25	272	406	485	560	656	681	702	
30	263	397	477	552	648	677	690	
33.5	255	389	468	544	635	656	673	

Resorcinol, C_1 ≎ 400 = 1M $C_6H_6O_2$ and 25M H_2O

t, °C	C_2 300	240	200	160	100	80	60	40	20
0	− 21	− 50	− 84	−125	−217	−251	−293	−343	−376
5	− 38	− 79	−113	−167	−272	−301	−360	−418	−468
10	− 54	−100	−142	−201	−309	−360	−418	−485	−560
15	− 67	−125	−171	−234	−364	−418	−481	−560	−635
20	− 84	−151	−205	−272	−410	−460	−544	−627	−744
25	−100	−176	−230	−314	−460	−527	−615	−744	−828
30	−117	−201	−268	−343	−502	−585	−669	−773	−920
33.5	−134	−226	−293	−376	−544	−619	−719	−836	−1003

Pyrocatechol, C_1 ≎ 400 = 1M $C_6H_6O_2$ and 25M H_2O

0	326	544	711	899	1187	1275	1359	1432
5	293	489	635	811	1070	1162	1233	1296
10	259	439	573	727	970	1045	1108	1171
15	226	376	502	635	840	920	983	1045
20	188	326	426	543	732	794	857	920
25	151	272	351	452	619	673	736	794
30	121	217	280	363.7	506	552	606	669
33.5	100	167	226	301.0	418	460	502	552

1/6Hydroquinol, C_1 ≎ 400 = 1M $C_6H_6O_2$ and 400M H_2O

0	10.0	13.8	14.2	12.5	− 3.3	−13.4		
5	6.3	8.4	8.4	6.3	− 7.9	−15.1		
10	3.8	4.2	3.3	0.4	−11.7	−18.0		
15	1.3	0	− 1.7	− 5.4	−15.1	−19.2		
20	− 2.1	− 5.0	− 7.5	−11.3	−20.1	−23.0		
25	− 5.9	−10.0	−13.0	−16.7	−23.0	−25.5		
30	− 8.8	−14.2	−17.1	−20.5	−25.5	−27.2		
33.5	−12.1	−18.4	−21.7	−24.2	−26.7	−27.2		

½Mannitol, C_1 ≎ 400 = 1M $C_6H_{14}O_6$ and 50M H_2O

0	4.2	3.8	2.1	− 3.3	−14.6			
5	6.7	8.4	6.7	5.0	− 0.8			
10	7.1	10.5	11.3	11.3	11.3			
15	7.5	12.5	15.1	19.2	25.1			
20	9.2	16.3	21.7	28.4	39.7			
25	9.2	16.7	23.8	33.0	50.2			
30	13.0	21.7	30.1	41.8	64.8			
33.5	13.4	23.8	33.4	46.8	76.9			

Dextrose, C_1 ≎ 400 = 1M $C_6H_{12}O_6.H_2O$ and 25M H_2O

0	167	268	343						
5	167	268	343						
10	167	268	343						
15	167	268	343						
20	167	268	343	431	560	606	652	690	
25	167	268	343	427	544	585	623	656	
30	167	268	343	418	527	560	594	623	
33.5	167	268	343	414	510	543	564	594	

Sucrose, C_1 ≎ 400 = 1M $C_{12}H_{22}O_{11}$ and 25M H_2O

0	247	393	481	564	673	707	736	769
5	247	393	485	573	694	732	773	815
10	247	397	493	585	719	761	807	857
15	247	397	497	594	744	794	849	916
20	247	401	502	606	769	824	891	962
25	247	401	510	619	790	853	924	1008
30	247	406	518	631	819	886	962	1054
33.5	247	410	522	644	836	907	991	1095

1.847 NaOH, C_1 ≎ 800 = 2M NaOH and 25M H_2O

t, °C	C_2 720	300	200	140	80	60	40	20
0	−63	−1534	−2279	−2885	−3617	−3847		
5	−42	−1200	−1831	−2300	−2835	−2989	−3169	−3345
10	−21	− 911	−1401	−1756	−2132	−2237	−2354	−2467
15	4	− 619	−1016	−1254	−1480	−1559	−1647	−1714
20	8	− 334	− 606	− 778	− 928	− 978	−1020	−1066
25	12	− 63	− 242	− 355	− 447	− 477	− 489	− 493
30	17	171	84	21	− 42	− 50	− 63	− 67
33.5	21	343	326	284	251	247	247	247

1.645 KOH, C_1 ≎ 800 = 2M KOH and 25M H_2O

t, °C	C_2 640	300	200	140	80	60	40
0	0	−355	−719	−1003	−1317	−1422	−1547
5	13	− 96	−385	− 544	− 753	− 828	− 899
10	25	138	4	− 100	− 209	− 251	− 293
15	38	355	326	284	251	251	263
20	50	560	606	652	690	719	773
25	63	744	870	953	1066	1129	1204
30	71	903	1087	1213	1392	1484	1589
33.5	79	983	1204	1346	1555	1651	1756

1.17 NH_4Cl, C_1 ≎ 400 = 1.17M NH_4Cl and 25M H_2O

t, °C	C_2 300	240	200	160	100	80	60	40	20
0	−255	−431	−556	−698	−920	−983	−1037	−1087	
2	−238	−397	−514	−640	−836	−899	− 937	− 978	
4	−230	−364	−472	−585	−757	−811	− 840	− 861	
6	−201	−334	−431	−535	−669	−711	− 744	− 753	
8	−184	−305	−389	−468	−594	−619	− 644	− 644	
10	−167	−276	−351	−418	−518	−544	− 552	− 552	
12	−151	−247	−309	−368	−452	−468	− 460	− 477	−334
14	−138	−230	−272	−318	−385	−393	− 385	− 339	−226
16	−125	−201	−238	−272	−314	−314	− 309	− 255	−142
18	−109	−167	−201	−226	−247	−238	− 222	− 167	− 42
20	− 92	−134	−163	−176	−176	−167	− 151	− 84	+ 84

NH_4Cl, C_1 ≎ 400 = 1M NH_4Cl and 25M H_2O

22	−63	−88	−96	−96	−96	−96	−96	−84	−21
24	−46	−59	−67	−67	−42	−25	8	71	159
26	−33	−42	−33	−29	4	33	84	155	251
28	−17	−13	0	13	59	84	142	234	334
30	− 4	8	25	42	100	125	192	272	385
32	8	33	50	71	134	167	209	293	418
33.5	21	46	67	92	155	192	230	305	439

KCl, C_1 ≎ 400 = 1M KCl and 25M H_2O

0	−594	−974	−1246	−1547	−2095	−2308	−2530	−2718	−2843
2	−564	−924	−1179	−1484	−2007	−2195	−2404	−2575	−2663
4	−543	−907	−1129	−1409	−1902	−2091	−2279	−2438	−2509
6	−518	−845	−1087	−1346	−1819	−1999	−2174	−2329	−2366
8	−481	−807	−1037	−1288	−1735	−1902	−2070	−2195	−2245
10	−460	−761	− 983	−1217	−1631	−1781	−1944	−2086	−2111
12	−439	−727	− 937	−1162	−1547	−1697	−1835	−1957	−1982
14	−418	−702	− 891	−1100	−1463	−1589	−1735	−1840	−1848
16	−397	−661	− 845	−1037	−1388	−1505	−1639	−1748	−1748
18	−376	−619	− 794	− 983	−1325	−1421	−1547	−1631	−1631
20	−355	−585	− 753	− 928	−1233	−1338	−1455	−1534	−1505
22	−326	−552	− 707	− 878	−1162	−1258	−1363	−1432	−1421
24	−313	−518	− 665	− 828	−1091	−1179	−1267	−1325	−1296
26	−293	−489	− 627	− 773	−1020	−1104	−1183	−1237	−1191
28	−280	−460	− 585	− 723	− 953	−1033	−1104	−1145	−1087
30	−272	−439	− 556	− 681	− 891	− 962	−1003	−1041	− 974
32	−251	−410	− 523	− 635	− 815	− 907	− 932	− 962	− 853
33.5	−238	−389	− 493	− 594	− 773	− 828	− 874	− 899	− 786

½$SrCl_2$, C_1 ≎ 400 = 1M $SrCl_2$ and 50M H_2O

14	−33	−54	−59	−46	−25	8	54	159	401
16	−17	−33	−13	13	54	88	146	251	493
18	0	33	33	63	134	171	230	334	585
20	21	50	84	121	209	251	309	427	669
22	42	92	134	184	276	330	389	506	753
24	59	117	163	217	334	389	460	585	828
26	75	142	197	268	414	460	535	669	911
28	92	171	230	314	456	514	594	744	978
30	117	201	272	351	506	577	661	799	1024
32	134	226	301	397	560	631	727	857	1095
33.5	146	251	330	426	602	677	773	920	1158

½$SrCl_2$, C_1 ≎ 400 = 1M $SrCl_2.6H_2O$ and 50M H_2O

0	−70	−117	−146	−184	−234				
2	−59	−100	−125	−151	−171				
4	−52	− 84	−105	−113	−125				
6	−46	− 71	− 75	− 84	− 88				
8	−40	− 59	− 54	− 54	− 54				
10	−33	− 42	− 38	− 38	− 29				
12	−25	− 25	− 25	− 17	+ 4				

½$BaCl_2$, C_1 ≎ 400 = 1M $BaCl_2$ and 25M H_2O

14	−125	−192	−226	−251	−272	−276	−251	−180	42
16	−105	−151	−167	−188	−192	−188	−146	− 63	167
18	− 84	−117	−125	−117	−105	− 8	− 42	50	251
20	− 63	− 75	− 75	− 63	− 17	4	59	163	376
22	− 42	− 42	− 38	0	63	92	159	255	447
24	− 21	4	38	59	134	167	247	343	573
26	0	33	63	109	201	251	314	426	635
28	21	63	109	167	280	326	401	510	732
30	42	105	151	226	347	397	489	552	794
32	63	134	201	272	418	468	564	594	857
33.5	84	163	226	309	460	523	615	619	920

½$BaCl_2$, C_1 ≎ 400 = 1M $BaCl_2.2H_2O$ and 50M H_2O

0	−226	−364	−468	−577	−753	−824	−903	−1003
2	−209	−330	−418	−514	−656	−702	−753	−811
4	−184	−293	−372	−452	−564	−598	−619	− 652
6	−155	−259	−322	−385	−472	−489	−502	− 502

$\frac{1}{2}BaCl_2$, C_1 = 400 = 1M $BaCl_2.2H_2O$ and 50M H_2O.—(*Cont'd*)

t, °C	C_2 300	240	200	160	100	80	60	40	20
8	−146	−230	−280	−330	−385	−393	−393	− 376	
10	−125	−197	−230	−268	−293	−293	−276	− 234	
12	−109	−163	−188	−205	−201	−192	−159	− 84	

NH_4NO_3, C_1 = 400 = 1M NH_4NO_3 and 25M H_2O

0	−1108	−1819	−2299	−2843	−3721	−4014	−4327	−4641	−5017
5	−1024	−1693	−2132	−2634	−3420	−3679	−3972	−4223	−4515
10	− 983	−1589	−1986	−2425	−3094	−3345	−3596	−3847	−4139
15	− 899	−1442	−1827	−2216	−2843	−3040	−3261	−3491	−3763
20	− 836	−1338	−1672	−2019	−2571	−2759	−2969	−3157	−3387
25	− 773	−1233	−1568	−1852	−2362	−2530	−2697	−2885	−3010
30	− 727	−1150	−1442	−1723	−2153	−2320	−2446	−2592	−2697
33.5	− 669	−1066	−1355	−1622	−2028	−2174	−2362	−2425	−2488

$NaNO_3$, C_1 = 400 = 1M $NaNO_3$ and 25M H_2O

0	−1233	−2007	−2659	−3261	−4348	−4725	−5184	−5561	−5895
5	−1087	−1798	−2333	−2885	−3847	−4223	−4599	−4975	−5226
10	−1003	−1647	−2132	−2634	−3512	−3847	−4181	−4515	−4766
15	− 911	−1497	−1915	−2375	−3178	−3470	−3763	−4056	−4265
20	− 836	−1380	−1756	−2174	−2885	−3178	−3408	−3658	−3805
25	− 769	−1254	−1631	−2007	−2592	−2822	−3044	−3219	−3387
30	− 690	−1154	−1497	−1840	−2341	−2542	−2709	−2885	−3010
33.5	− 661	−1087	−1396	−1714	−2174	−2341	−2475	−2592	−2676

KNO_3, C_1 = 400 = 1M KNO_3 and 25M H_2O

0	−1547	−2634	−3408	−4348	−6062	−6815	−7526	−8362	−9073
5	−1505	−2509	−3219	−4014	−5561	−6104	−6690	−7359	−8069
10	−1421	−2341	−2969	−3721	−5059	−5519	−6021	−6564	−7108
15	−1338	−2174	−2843	−3512	−4683	−5101	−5519	−5979	−6439
20	−1212	−2007	−2592	−3219	−4348	−4683	−5101	−5519	−5853
25	−1150	−1923	−2425	−3094	−4014	−4390	−4725	−5101	−5477
30	−1095	−1840	−2383	−2885	−3805	−4139	−4474	−4808	−5101
33.5	−1045	−1756	−2258	−2759	−3721	−3930	−4181	−4515	−4808

$\frac{1}{2}Ba(NO_3)_2$, C_1 = 400 = 1M $Ba(NO_3)_2$ and 25M H_2O

0	−197	−334	−443	−564	−761	−836	−911	−1003	−1087
5	−171	−293	−376	−468	−640	−702	−761	− 836	−1003
10	−151	−255	−334	−418	−556	−606	−665	− 711	− 732
15	−138	−226	−293	−364	−472	−514	−552		
20	−125	−201	−255	−314	−401	−431	−460		
25	−113	−176	−222	−268	−351	−376	−389		
30	− 96	−159	−192	−251	−318	−330	−334		
33.5	− 84	−146	−176	−234	−284				

$\frac{1}{2}Sr(NO_3)_2$, C_1 = 400 = 1M $Sr(NO_3)_2$ and 50 MH_2O

t, °C	C_2 300	240	200	160	100	80	60	40	20
0	−978	−1568	−2049	−2571	−3512	−3847	−4181	−4641	−5184
5	−911	−1497	−1902	−2363	−3177	−3428	−3742	−4076	−4453
10	−832	−1359	−1735	−2132	−2835	−3073	−3324	−3617	−3888
15	−753	−1212	−1568	−1923	−2530	−2718	−2948	−3157	−3387
20	−686	−1108	−1401	−1714	−2216	−2404	−2592	−2739	−2843
25	−602	− 974	−1233	−1526	−1965	−2091	−2216	−2341	
30	−518	− 845	−1087	−1321	−1706	−1819	−1902	−2007	
33.5	−435	− 732	− 983	−1171	−1526	−1589	−1672	−1735	

Heat of Dilution of Aqueous Solutions of Ethyl and Methyl Alcohols

If m grams of water are added to M grams of solution containing N gram-molecular-weights of the alcohol per 1000 g of H_2O the heat (Q) evolved per mole of water added is given by

$$Q = A - 10^{-3} \times Bm, \text{ g-cal}_{20}/\text{Mole}$$
$$Q = a - 10^{-3} \times bm, \text{ joule/Mole}$$

up to m = 800 g. All weights *in vacuo*. t = 25°C. Braham, Atmospheric Nitrogen Corporation, Syracuse, N. Y., *O.* MacInnes and Braham, *1*, **39**: 2110; 17.

N	C_2H_5OH, M = 9611 g* A	B	a	b	CH_3OH, M = 9600 g† A	B	a	b
1	2.00	0.51	8.37	2.13	1.10	0.00	4.22	0.00
2	8.80	1.38	36.8	5.78	4.44	0.21	18.6	0.88
3	21.85	2.481	91.4	10.38	10.30	0.825	43.10	3.45
4	40.60	4.450	170.0	18.63	18.53	1.8	77.5	

* $A = 0.56N + 0.80N^2 + 0.72N^3 - 0.08N^4$.
$a = 2.345N + 3.35N^2 + 3.013N^3 - 0.335N^4$.
† $A = -0.20N + 1.21N^2$.
$a = -0.837N + 5.03N^2$.

HEATS OF COMBUSTION OF ORGANIC COMPOUNDS

Source of the Data

All of the values given in this section have been taken from the critical compilation by Kharasch (1) to which the reader is referred for bibliography and critical discussion.

Units

The values recorded in the tables are expressed in 1922 International Combustion Calories[1] per gram-formula-weight (*in vacuo*) of substance in the **liquid state** (unless otherwise indicated by g = gas and s = solid) when the combustion takes place at **constant pressure** (1 atm.) and at 18 − 20°C, to form gaseous CO_2 and N_2, liquid H_2O, and such compounds of other elements present as are indicated under the individual entries.

Standard Substances for Combustion Calorimetry

Primary Standard.—The Third Conference of the International Union of Pure and Applied Chemistry (Lyons, 1922) adopted the benzoic acid standard with the following values: Q = 6 324 g-cal_{15} (=26 466 abs. j.) per gram in air; =6 319 g-cal_{15} (=26 445 abs. j.) per gram *in vacuo; cf.* (3, 5). These values define what may be called the "1922 International Combustion Calorie."

[1] Calories instead of joules have been employed in this section in deference to the wishes of the Committee on Thermochemistry of the International Union of Pure and Applied Chemistry.

Proposed Secondary Standard.—Salicylic acid, Q = 5 242 g-cal_{15} (=22 699 abs. j.) per gram in air; =5 238 g-cal_{15} (=21 921 abs. j.) per gram *in vacuo* (4).

Other Standards.—The best values for cane sugar and naphthalene may be obtained from the following carefully determined ratios of Q per gram in air (2).

$$\frac{\text{Naphthalene}}{\text{Benzoic acid}} = 1.5201. \quad \frac{\text{Benzoic acid}}{\text{Sugar}} = 1.6028. \quad \frac{\text{Naph.}}{\text{Sugar}} = 2.4364$$

Calculation of Heat of Combustion from Structural Formula

The heat of combustion of any organic compound in the liquid state may be calculated from its structural formula with an accuracy, in most cases, of better than 1%. For most purposes for which heats of combustion are required this accuracy is sufficient. Indeed it is equal to or better than the accuracy of most of the experimental values now available. For a full description of the method of calculation and comparison between observed and calculated values, *see* (1).

Heats of Formation

The heat of formation, H, of any compound ($C_aH_bBr_cCl_dF_eI_fN_gO_hS_i$) out of its elements in their standard states (*v.* p. 169) may be calculated from its heat of combustion, Q, as given below, by means of the equation $H = (-Q + 94.38a + 34.19b +$

$0 \times c + 0 \times d + 75.6e + 0 \times f + 0 \times g + 0 \times h + 69.3i$) kg-cal$_{15}$.

This equation applies where the products of combustion are $CO_2(g)$, $H_2O(l)$, $Br_2(l)$, $Cl_2(g)$, HF dilute aqueous solution, $I_2(s)$, $N_2(g)$, $SO_2(g)$. If the products of combustion are:

$HBr(aq)$, the numerical coefficient of c is 28.54.

$HCl(aq)$, the numerical coefficient of d is 39.46.

HNO_3aq, the numerical coefficient of g is 49.80.

H_2SO_4aq, the numerical coefficient of i is 207.5.

To obtain H in kj per g.f.w. multiply by 4.185 the value given by the above equation.

Tables

The compounds are arranged in groups as follows:

1. (C, H), Hydrocarbons.
2. (C, H, O), Alcohols (carbinols).
3. (C, H, O), Carboxylic acids.
4. (C, H, O), Acid anhydrides and lactones.
5. (C, H, O), Carbohydrates (sugars, starch, cellulose, etc.).
6. (C, H, O), Other C, H, O-compounds.
7. Nitrogen compounds.
8. Halogen compounds.
9. Sulfur compounds.

Formula	Name	kg-cal$_{15}$ per mole
	1. Hydrocarbons	
CH_4	Methane (g)	210.8*
C_2H_2	Acetylene (ethine) (g)	312.0
C_2H_4	Ethylene (g)	332
C_2H_6	Ethane (g)	368.4†
C_3H_4	Allylene (propine) (g)	456.1‡
		473.0§
C_3H_6	Propylene	490.2
C_3H_6	Trimethylene (g)	496.8
C_3H_8	Propane (g)	526.3‖
C_4H_8	Isobutylene (g)	647.2
C_4H_{10}	Isobutane (trimethylmethane) (g)	683.4¶
C_5H_{10}	Amylene	803.4
C_5H_{10}	Cyclopentane	783.6
C_5H_{10}	Methylcyclobutane	784.2
C_5H_{10}	Trimethylethylene (g)	803.6
	(liquid)	796.0
C_5H_{12}	Isopentane (g)	843.5
C_5H_{12}	(liquid)	838.3
C_5H_{12}	n-Pentane (g)	838.3
C_5H_{12}	(liquid)	833.4
C_5H_{12}	Tetramethylmethane	842.6(?)
C_6H_6	Benzene (g)	787.2
C_6H_6	(liquid)	783.4
C_6H_6	Dimethyldiacetylene (2, 4-hexadiine)	847.8
C_6H_6	Dipropargyl (1, 5-hexadiine)	853.5**
		882.9††
C_6H_8	Dihydrobenzene	833.2‡‡
		847.8§§
C_6H_{10}	Bicyclohexane (0, 1, 3)	912.5
C_6H_{10}	Diallyl (g)	928.1††
		903.4**
C_6H_{10}	Dimethylmethylenecyclopropane	898.0
C_6H_{10}	Tetrahydrobenzene (cyclohexene)	892
C_6H_{12}	Cyclohexane	939
C_6H_{12}	Hexylene	952.6
C_6H_{12}	Methylcyclopentane	937.9
C_6H_{14}	Diisopropyl (g)	993.9
C_6H_{14}	n-Hexane	990.6
C_7H_8	Toluene	936
C_7H_{12}	Bicycloheptane	1030.3
C_7H_{12}	Cycloheptene	1049.9
C_7H_{12}	Heptine-1	1091.2
C_7H_{12}	Methylenecyclohexane	1050
C_7H_{12}	1-Methyl-3-cyclohexene	1043.6
C_7H_{12}	1-Methyl-1-cyclohexene	1040.9‡‡
		1048.1‖‖
C_7H_{14}	Cycloheptane	1087.3
C_7H_{14}	1, 3-Dimethylcyclopentane	1090.7
C_7H_{14}	Methylcyclohexane	1091.3
C_7H_{16}	2, 2-Dimethylpentane	1148.9
C_7H_{16}	2, 3-Dimethylpentane	1148.9
C_7H_{16}	2, 4-Dimethylpentane	1148.9
C_7H_{16}	3, 3-Dimethylpentane	1147.9
C_7H_{16}	3-Ethylpentane	1149.9
C_7H_{16}	n-Heptane	1149.9
C_7H_{16}	2-Methylhexane	1148.9
C_7H_{16}	3-Methylhexane	1148.9
C_7H_{16}	2, 2, 3-Trimethylbutane	1147.9
C_8H_6	Phenylacetylene (phenylethine)	1024.2
C_8H_8	Styrene (phenylethylene)	1046
C_8H_{10}	Ethylbenzene	1091.2
C_8H_{10}	o-Xylene	1093
C_8H_{10}	m-Xylene	1089.6
C_8H_{10}	p-Xylene	1089.1
C_8H_{12}	1, 4-Dimethylcyclohexa-1, 3-diene	1152.2
C_8H_{12}	1, 3-Dimethyldihydrobenzene	1148.2
C_8H_{12}	1, Methyl-3-methylene-1-cyclohexene	1149.2
C_8H_{14}	1, 3-Dimethyl-3-cyclohexene	1194.5
C_8H_{14}	Ethylenecyclohexane	1207.7
C_8H_{14}	1-Ethyl-1-cyclohexene	1203.7
C_8H_{14}	Laurolene	1192.7
C_8H_{14}	i-Laurolene (1, 1, 2-trimethylcyclopent-2-ene)	1193.3
C_8H_{16}	1, 1-Dimethylcyclohexane	1242.8
C_8H_{16}	1, 3-Dimethylcyclohexane	1238(?)
C_8H_{16}	1, 4-Dimethylcyclohexane	1229(?)
C_8H_{16}	Diisobutylene	1252.4
C_8H_{16}	Methylcycloheptane	1244.5
C_8H_{18}	1, 2, 4-Trimethylcyclopentane	1245.4
C_8H_{18}	2, 5-Dimethylhexane	1303.3
C_8H_{18}	3, 4-Dimethylhexane	1303.7
C_8H_{18}	3-Ethylhexane	1302.3
C_8H_{18}	Hexamethylethane (s)	1301.8
C_8H_{18}	2-Methylheptane	1306.1
C_8H_{18}	n-Octane	1305
C_8H_{18}	2, 2, 4-Trimethylpentane	1303.9
C_9H_{10}	α-Methylstyrene	1202.9
C_9H_{10}	β-Methylstyrene (p-tolylethylene)	1202.4
C_9H_{12}	Isopropylbenzene	1247.3
C_9H_{12}	Mesitylene	1243.6
C_9H_{12}	n-Propylbenzene	1246.4
C_9H_{12}	Pseudocumene (1, 2, 4-trimethylbenzene)	1241.7
C_9H_{14}	1-Methyl-4-ethylcyclohexa-1, 3-diene	1310.8
C_9H_{16}	1-Isopropylcyclohex-1-ene	1340.8
C_9H_{18}	Ethylcycloheptane	1406.8
C_9H_{18}	Methyl-1-n-propylcyclopentane	1401.3
C_9H_{18}	1, 3, 3-Trimethylcyclohexane	1395(?)
C_9H_{18}	1, 2, 3-Trimethylcyclohexane	1396.0
C_9H_{18}	1, 3, 4-Trimethylcyclohexane	1383(?)
$C_{10}H_8$	Naphthalene (s)	1231.8
$C_{10}H_{10}$	Δ^1-Dihydronaphthalene	1300
$C_{10}H_{10}$	Δ^2-Dihydronaphthalene (s)	1298.3
$C_{10}H_{10}$	1-Phenyl-3-butine	1340.0
$C_{10}H_{12}$	α-β-Dimethylstyrene (s)	1357.2
$C_{10}H_{12}$	β-Ethylstyrene	1346.1
$C_{10}H_{12}$	1-Phenyl-3-butene	1356.9
$C_{10}H_{12}$	1-Phenyl-2-butene	1361.2
$C_{10}H_{12}$	Tetrahydronaphthalene	1340
$C_{10}H_{14}$	*tert.*-Butylbenzene	1400.4
$C_{10}H_{14}$	Hexahydronaphthalene	1419.3
$C_{10}H_{14}$	4-Isopropyltoluene (cymene)	1405
$C_{10}H_{14}$	3-n-Propyltoluene	1405
$C_{10}H_{14}$	3-Isopropyltoluene	1409
$C_{10}H_{14}$	1, 2, 4, 5-Tetramethylbenzene (durol) (s)	1393.6
$C_{10}H_{15}$	Borneocamphene	1470.2
$C_{10}H_{16}$	Camphene (s)	1468
$C_{10}H_{16}$	d-"Citrene"	1473.0
$C_{10}H_{16}$	Cyclene (tricyclene) (s)	1467.3
$C_{10}H_{16}$	1, 5-Dimethyl-3-vinyl-1-cyclohexene	1455.7
$C_{10}H_{16}$	1-Isobutenyl-1-cyclohexene	1461.8
$C_{10}H_{16}$	d-Limonene	1471.2
$C_{10}H_{16}$	l-Limonene	1457.2
$C_{10}H_{16}$	1-Methyl-4-isopropylcyclohexa-1, 3-diene	1470.7

* Average of nine determinations, max. d. = 1.1 %.
† Max. d. = 1.1 %.
‡ Thomsen.
§ Berthelot.
‖ Max. d. = 0.9 %.
¶ Max. d. = 0.4 %.
** Berthelot.
†† Thomsen.
‡‡ Swietoslawski.
§§ Stohmann.
‖‖ Roth and Auwers.

Formula	Name	kg-cal$_{15}$ per mole
	1. HYDROCARBONS.—(*Continued*)	
$C_{10}H_{16}$	Octohydronaphthalene	1461.7
$C_{10}H_{16}$	*d*-α-Pinene (australene)	1471.9
$C_{10}H_{16}$	*l*-α-Pinene (terebenthene)	1477
$C_{10}H_{16}$	β-Pinolene	1469.8
$C_{10}H_{16}$	Sylvestrene	1464.7
$C_{10}H_{16}$	Terecamphene (inact.)	1466.7
$C_{10}H_{16}$	α-Terpinene	1470.4
$C_{10}H_{18}$	*cis*-Decahydronaphthalene	1502.5
$C_{10}H_{18}$	*trans*-Decahydronaphthalene	1498
$C_{10}H_{18}$	1-Ethyl-5-dimethylcyclohexene	1504.5
$C_{10}H_{18}$	Fenchane	1502.8
$C_{10}H_{18}$	Menthene (Δ^1-terpene) (Δ^3-menthene)	1523.2
$C_{10}H_{18}$	Thujane	1506.4
$C_{10}H_{20}$	Diamylene	1582.2
$C_{10}H_{20}$	*p*-Menthane (1-isopropyl-4-methylcyclohexane)	1514(?)
$C_{10}H_{20}$	Methyl-*l*-*n*-propyl-3-cyclohexane	1502.9
$C_{10}H_{22}$	Decane	1610.2
$C_{10}H_{22}$	Diisoamyl	1615.8
$C_{11}H_{14}$	1-Phenyl-2-pentene	1510.0
$C_{11}H_{16}$	Pentamethylbenzene (*s*)	1554.0
$C_{11}H_{18}$	1, 5-Dimethyl-3-isopropene-1-cyclohexene	1615.0
$C_{12}H_{10}$	Acenaphthene (*s*) (periethylenenaphthylene)	1491.8
$C_{12}H_{10}$	Diphenyl (*s*)	1493.6
$C_{12}H_{16}$	β, β-Diethylstyrene	1664.9
$C_{12}H_{18}$	Hexamethylbenzene (*s*)	1711.9
$C_{12}H_{24}$	Triisobutylene $[(CH_3)_2CHC(CH_3CH(CH_3)_2):CHCH(CH_3)_2]$	1858.8
$C_{13}H_{10}$	Fluorene (*s*)	1584.9
$C_{13}H_{12}$	Diphenylmethane (*s*)	1655.0
$C_{14}H_{10}$	Anthracene (*s*)	1695
$C_{14}H_{10}$	Phenanthrene (*s*)	1693
$C_{14}H_{12}$	Stilbene (*sym.*-diphenylethylene) (*s*)	1765.0
$C_{14}H_{12}$	Isostilbene	1770.9
$C_{14}H_{14}$	Dibenzyl (*s*)	1810.6
$C_{14}H_{26}$	3, 3-Dimethyldicyclohexyl(*m*-hexahydrotolyl)	2106
$C_{15}H_{14}$	α-β-Methylphenylstyrene (*s*)	1929
$C_{16}H_{10}$	Diphenyldiacetylene (*s*)	1975.6
$C_{16}H_{14}$	Diphenylbutadiene (*s*)	2057
$C_{16}H_{14}$	*cis-cis*-Diphenylbutadiene (*s*)	2035
$C_{16}H_{14}$	*trans-trans*-Diphenylbutadiene (*s*)	2030
$C_{16}H_{34}$	Hexadecane (*s*)	2559
$C_{18}H_{12}$	Chrysene (*s*)	2139
$C_{18}H_{16}$	Diphenylhexatriene (*s*)	2288(?)
$C_{18}H_{18}$	Dibenzylbutadiene (*s*)	2341
$C_{18}H_{18}$	1, 6-Diphenylhexa-1, 5-diene (*s*)	2342
$C_{18}H_{18}$	Retene (*s*) (methylisopropylphenanthrene)	2307
$C_{18}H_{20}$	1, 4-Diphenyl-1-ethyl-3-butene	2372
$C_{19}H_{16}$	Triphenylmethyl (*s*)	2378
$C_{19}H_{16}$	Triphenylmethane (*s*)	2384
$C_{20}H_{16}$	Diphenylstyrene (*s*)	2496
$C_{20}H_{42}$	Eicosane (*s*)	3183
$C_{24}H_{18}$	1, 3, 5-Triphenylbenzene (*s*)	2937
$C_{25}H_{20}$	Tetraphenylmethane (*s*)	3102
$C_{28}H_{20}$	Dianthracene (*s*)	3383
	2. ALCOHOLS	
CH_4O	Methyl alcohol	170.9
C_2H_6O	Ethyl alcohol	328
$C_2H_6O_2$	Glycol	281.9
C_3H_4O	Propargyl alcohol (*g*)	428.9
C_3H_6O	Allyl alcohol	442.4
C_3H_8O	*n*-Propyl alcohol	482
C_3H_8O	Isopropyl alcohol	474.8
$C_3H_8O_2$	Propylene glycol	431.0
$C_3H_8O_2$	Isopropylene glycol	436.1
$C_3H_8O_3$	Glycerol	397.0
$C_4H_{10}O$	*n*-Butyl alcohol	639
$C_4H_{10}O$	Isobutyl alcohol (primary)	638.2
$C_4H_{10}O$	Trimethyl carbinol (*tert.*-butyl)	629.3
$C_4H_{10}O_2$	Diethylene glycol	567
$C_4H_{10}O_4$	Erythritol (*s*)	504.1
$C_5H_{10}O$	Cyclobutyl carbinol	748
$C_5H_{10}O$	Ethyl vinyl carbinol	753
$C_5H_{10}O_2$	Dihydroxymethylcyclopropane	708
$C_5H_{10}O_2$	Cyclopentan-1, 2-diol (*cis*)	696.1
$C_5H_{10}O_2$	Cyclopentan-1, 2-diol (*trans*)	694.2
$C_5H_{12}O$	Amyl alcohol (?)	787
$C_5H_{12}O$	Amyl alcohol (ferm.)*	792
$C_5H_{12}O$	Dimethyl ethyl carbinol	785

* Mostly isobutyl carbinol.

Formula	Name	kg-cal$_{15}$ per mole
$C_5H_{12}O_4$	Pentaerythritol (*s*)	661
$C_5H_{12}O_5$	Arabitol (*s*)	612
$C_6H_{12}O$	Allyldimethyl carbinol	886.5†
		913.7‡
$C_6H_{12}O$	Cyclohexanol	891
$C_6H_{12}O$	β-Methylcyclopentanol	888
$C_6H_{12}O_2$	Cyclohexan-1, 2-diol (*cis*)	841.6
$C_6H_{12}O_2$	Cyclohexan-1, 2-diol (*trans*)	842.7
$C_6H_{12}O_6$	Quercitol (*s*)	704
$C_6H_{12}O_6$	Inositol (inosite) (*s*)	662
$C_6H_{14}O$	Pinacolyl alcohol	939
$C_6H_{14}O$	Methyldiethyl carbinol	927
$C_6H_{14}O_2$	Pinacol (*s*)	897.6
$C_6H_{14}O_6$	Dulcitol (*s*)	729.1§
		723.7‖
$C_6H_{14}O_6$	*d*-Mannitol (*s*)	727.6
C_7H_8O	Benzyl alcohol	893
$C_7H_{12}O$	Diallyl carbinol	1028
$C_7H_{14}O$	Allylmethylethyl carbinol	1050.1
$C_7H_{14}O$	Cycloheptanol	1050.2
$C_7H_{14}O$	Cyclohexyl carbinol	1047.2
$C_7H_{14}O$	1, 3-Dimethylcyclopentan-2-ol	1030.5
$C_7H_{14}O$	1, 3-Dimethylcyclopentan-3-ol	1034.0
$C_7H_{14}O$	1-Ethylcyclopentan-2-ol	1039
$C_7H_{14}O$	β-Methylcyclohexanol	1038
$C_7H_{14}O_2$	*cis*-1-Methylcyclohexan-1, 2-diol	992.6
	trans-1-Methylcyclohexan-1, 2-diol	995.1
$C_7H_{16}O$	*n*-Heptyl alcohol	1104.9
$C_7H_{16}O$	Triethyl carbinol	1080
$C_7H_{16}O_7$	Perseitol (*d*-mannoheptol) (*s*)	836
$C_8H_{14}O$	Amylpropargyl alcohol¶	1192
$C_8H_{14}O$	Diallylmethyl carbinol	1181
$C_8H_{14}O_2$	Tetramethylbutindiol	1142
$C_8H_{16}O$	Allyldiethyl carbinol	1207
$C_8H_{16}O$	Allylmethylpropyl carbinol	1202
$C_8H_{16}O$	1, 2-Dimethylcyclohexan-2-ol	1196.5
$C_8H_{16}O$	1, 3-Dimethylcyclohexan-2-ol	1196
$C_8H_{16}O$	1, 3-Dimethylcyclohexan-3-ol	1192.5
$C_8H_{16}O$	1, 3-Dimethylcyclohexan-5-ol	1183
$C_8H_{16}O_2$	Tetramethylbutenediol (fumaroid)	1176
$C_8H_{16}O_2$	Tetramethylbutenediol (maleinoid) (*s*)	1172
$C_8H_{18}O$	Octyl alcohol	1262
$C_8H_{18}O$	Methyldipropyl carbinol	1233
C_9H_8O	Phenylpropargyl alcohol**	1137
$C_9H_{10}O_2$	Hydrinden-1, 2-diol (*cis*)	1098.5
$C_9H_{10}O_2$	Hydrinden-1, 2-diol (*trans*)	1096.7
$C_9H_{16}O$	Hexylpropargyl alcohol	1340
$C_9H_{16}O$	1, 3, 5-Trimethylcyclohex-6-en-5-ol	1295
$C_9H_{18}O$	Allylmethyl-*n*-butyl carbinol	1365
$C_9H_{18}O$	Allylmethyl-*tert.*-butyl carbinol	1363
$C_9H_{18}O$	Cycloheptylmethyl carbinol	1342
$C_9H_{18}O$	1-Methyl-3-ethylcyclohexan-3-ol	1322
$C_9H_{20}O$	Ethyldipropyl carbinol	1386.5
$C_{10}H_{12}O_2$	1, 2, 3, 4-Tetrahydronaphthalenediols, all forms	1250
$C_{10}H_{18}O$	Borneol (synthetic)	1466
$C_{10}H_{18}O$	Borneol (Borneo camphor)	1470
$C_{10}H_{18}O$	α-Borneol (*s*)	1466.6
$C_{10}H_{18}O$	*l*-Borneol	1467.2
$C_{10}H_{18}O$	Diallylpropyl carbinol	1472
$C_{10}H_{18}O$	Terpineol (*s*)	1469 to 1480
$C_{10}H_{18}O$	Thujyl alcohol	1477.5
$C_{10}H_{20}O$	Allyldipropyl carbinol	1518.0††
		1549.6‡‡
$C_{10}H_{20}O$	Menthol (*s*)	1509
$C_{10}H_{22}O_2$	Terpinehydrate (*s*)	1451
$C_{11}H_{22}O$	Allylmethylhexyl carbinol	1667
$C_{12}H_{16}O_2$	1-Phenylcyclohexan-1, 2-diol (*cis* and *trans*)	1564
$C_{13}H_{12}O$	Diphenyl carbinol (*s*)	1615
$C_{14}H_{14}O_2$	Hydrobenzoin (*s*)	1723
$C_{14}H_{14}O_2$	Isohydrobenzoin (*s*)	1728
$C_{14}H_{18}O$	Amylphenylpropargyl alcohol	1901
$C_{16}H_{34}O$	Cetyl alcohol (*s*)	2504
$C_{19}H_{16}O$	Triphenyl carbinol (*s*)	2341
$C_{21}H_{16}O$	Diphenylphenylethinyl carbinol	2572

† Swietoslawski.
‡ Louguinine.
§ Berthelot.
‖ Stohmann.
¶ $C_5H_{11}.C{:}C.CH_2OH$.
** $C_6H_5.C{:}C.CH_2OH$.
†† Swietoslawski.
‡‡ Louguinine.

Formula	Name	kg-cal$_{15}$ per mole
	3. C, H, O, Acids	
CH_2O_2	Formic	62.8
$C_2H_2O_4$	Oxalic (*s*)	60.1$_5$
$C_2H_4O_2$	Acetic	209.4*
		207.1†
$C_2H_4O_3$	Glycolic (*s*)	166.6
$C_3H_4O_4$	Dihydroxyacetic (glyoxylic) (*s*)	125.5
$C_3H_4O_2$	Acrylic	327.5
$C_3H_4O_3$	Pyroracemic, pyruvic	279.1
$C_3H_4O_4$	Malonic (*s*)	206.8
$C_4H_4O_5$	Tartronic (*s*)	165.4
$C_3H_4O_5$	Mesoxalic (dihydroxymalonic) (*s*)	128.2
$C_3H_6O_2$	Propionic	365
$C_3H_6O_3$	Lactic (*s*)	326.0
$C_4H_2O_4$	Acetylenedicarboxylic (*s*)	305.9
$C_4H_4O_2$	Tetrolic (*s*)	452.4
$C_4H_4O_4$	Fumaric (*trans*) (*s*)	320.0
$C_4H_4O_4$	Maleic (*cis*) (*s*)	326.1
$C_4H_6O_2$	Crotonic (*s*)	477.7
$C_4H_6O_2$	Trimethylenecarboxylic	481
$C_4H_6O_4$	Methylmalonic (*s*)	363.6
$C_4H_6O_4$	Succinic (*s*)	356.8
$C_4H_6O_5$	*l*-Malic	320.1
$C_4H_6O_5$	*d*-Tartaric (*s*)	275.1
$C_4H_6O_6$	*dl*-Tartaric (anhydr.) (*s*)	273.0
$C_4H_6O_6$	Mesotartaric (*s*)	276.0
$C_4H_8O_2$	*n*-Butyric	520
$C_4H_8O_2$	Isobutyric	517.4
$C_4H_8O_2$	Hydroxyisobutyric (*s*)	471.8
$C_4H_8O_3$	*dl*-β-Hydroxybutyric (*s*)	487.9
$C_5H_4O_3$	Pyromucic (*s*)	489.7
$C_5H_4O_4$	*cis*-Citraconic (methylmaleic) (*s*)	479.1
$C_5H_6O_4$	Itaconic (methylenesuccinic) (*s*)	475.3
$C_5H_6O_4$	*trans*-Mesaconic (methylfumaric) (*s*)	476.4
$C_5H_8O_4$	α, α-Trimethylenedicarboxylic (*s*)	483
$C_5H_8O_4$	α, β-Trimethylenedicarboxylic (*s*)	484
$C_5H_8O_2$	Allylacetic	641.6
$C_5H_8O_2$	Angelic (*s*)	634.8
$C_5H_8O_2$	α, β-Pentenic (*s*)	623.7
$C_5H_8O_2$	β, γ-Pentenic (*s*)	632.2
$C_5H_8O_2$	Tetramethylenecarboxylic	640
$C_5H_8O_2$	Tiglic (*s*)	626.4
$C_5H_8O_3$	Levulinic (β-acetylpropionic) (*s*)	576.8
$C_5H_8O_4$	Dimethylmalonic (*s*)	515.1
$C_5H_8O_4$	Ethylmalonic (*s*)	517.7
$C_5H_8O_4$	Glutaric (*s*)	514.8
$C_5H_8O_4$	Methylsuccinic (*s*)	515.3
$C_5H_8O_7$	Trihydroxyglutaric (*s*)	388.3
$C_5H_{10}O_2$	*n*-Valeric	679
$C_6H_6O_6$	Aconitic (*s*)	475.1
$C_6H_8O_2$	Sorbic (*s*)	743
$C_6H_8O_4$	Allylmalonic (*s*)	638
$C_6H_8O_4$	α, β-Hydromuconic (*s*)	628.8
$C_6H_8O_4$	β, γ-Hydromuconic (*s*)	629.1
$C_6H_8O_4$	α, α-Tetramethylenedicarboxylic (*s*)	642.0
$C_6H_8O_4$	α, β-Tetramethylenedicarboxylic (*s*)	642.1
$C_6H_8O_4$	α, γ-Tetramethylenedicarboxylic (*s*)	639.4
$C_6H_8O_6$	Tricarballylic (*s*)	516.0
$C_6H_8O_7$	Citric (anhydr.) (*s*)	474.5
$C_6H_8O_7.H_2O$	Citric (cryst.) (*s*)	471.4
$C_6H_{10}O_3$	Hydrosorbic	795
$C_6H_{10}O_4$	Adipic (*s*)	668.8
$C_6H_{10}O_4$	*sym.*-Dimethylsuccinic (*anti*) (*s*)	674.2
$C_6H_{10}O_4$	*sym.*-Dimethylsuccinic (*anti*) (*s*)	673.0
$C_6H_{10}O_4$	*dl-sym.*-Dimethylsuccinic (*s*)	671.5
$C_6H_{10}O_4$	*sym.*-Dimethylsuccinic (*para*) (*s*)	670.6
$C_6H_{10}O_4$	*unsym.*-Dimethylsuccinic (*s*)	671
$C_6H_{10}O_4$	Ethylsuccinic (*s*)	671.2
$C_6H_{10}O_4$	Methylethylmalonic (*s*)	672
$C_6H_{10}O_4$	α-Methylglutaric (*s*)	670.6
$C_6H_{10}O_4$	Propylmalonic (*s*)	674
$C_6H_{10}O_4$	Isopropylmalonic (*s*)	674
$C_6H_{10}O_6$	Allomucic (*s*)	494.2
$C_6H_{10}O_8$	Mucic (*s*)	483.6
$C_6H_{12}O_2$	Caproic	831.0‡
		838.2§
$C_6H_{12}O_2$	Diethylacetic	831

* Berthelot.
† Roth.
‡ Sweitoslawski
§ Fischer and Wrede.

Formula	Name	kg-cal$_{15}$ per mole
$C_6H_{12}O_2$	Isobutylacetic	833
$C_7H_4O_7$	Meconic (*s*)	490.8
$C_7H_6O_2$	Benzoic (*s*)	711.2‖
$C_7H_6O_3$	Salicylic (*s*)	723.1
$C_7H_6O_3$	*m*-Hydroxybenzoic (*s*)	725.1
$C_7H_6O_3$	*p*-Hydroxybenzoic (*s*)	724.6
$C_7H_6O_4$	2, 4-Dihydroxybenzoic (*s*)	676.5
$C_7H_6O_5$	Gallic (*s*)	633.7
$C_7H_6O_5$	Pyrogallolcarboxylic (*s*)	633.4
$C_7H_6O_8$	α, α, β, β-Trimethylenetetracarboxylic (*s*)	482.7
$C_7H_{10}O_2$	Δ_1-Tetrahydrobenzoic (*s*)	857
$C_7H_{10}O_2$	Δ_2-Tetrahydrobenzoic (*s*)	886
$C_7H_{10}O_4$	α, β-Pentamethylenedicarboxylic (*s*)	781.5
$C_7H_{10}O_4$	Teraconic acid (γ-dimethylitaconic) (*s*)	796
$C_7H_{12}O_2$	Hexahydrobenzoic	934
$C_7H_{12}O_4$	Diethylmalonic (*s*)	829
$C_7H_{12}O_4$	Pimelic (isopropylsuccinic)	827
$C_7H_{12}O_4$	Trimethylsuccinic (*s*)	829.9
$C_7H_{14}O_2$	Ethylpropylacetic	990
$C_7H_{14}O_2$	Heptylic	986.1
$C_8H_6O_4$	*o*-Phthalic (*s*)	771.0
$C_8H_6O_4$	Isophthalic (*s*)	768.3
$C_8H_6O_4$	Terephthalic (*s*)	770.4
$C_8H_6O_4$	Piperonylic (*s*)	803.5
$C_8H_8O_2$	Phenylacetic (*s*)	930
$C_8H_8O_2$	*o*-Toluic (*s*)	928.9†
		921.0**
$C_8H_8O_2$	*m*-Toluic (*s*)	928.6¶
		922.2**
$C_8H_8O_2$	*p*-Toluic (*s*)	926.9¶
$C_8H_8O_3$	*o*-Hydroxymethylbenzoic (*s*)	887.3
$C_8H_8O_3$	1, 2, 3-Hydroxytoluic†† (*s*)	878.7
$C_8H_8O_3$	1, 2, 4-Hydroxytoluic†† (*s*)	877.8
$C_8H_8O_3$	1, 2, 5-Hydroxytoluic†† (*s*)	879.5
$C_8H_8O_3$	1, 2, 6-Hydroxytoluic†† (*s*)	882.8
$C_8H_8O_3$	Mandelic (*s*)	890
$C_8H_8O_3$	*p*-Methoxybenzoic (*s*)	894.6
$C_8H_8O_3$	Phenoxyacetic (*s*)	903
$C_8H_8O_4$	Dihydroterephthalic (*s*)	842.6
$C_8H_8O_4$	$\Delta^{1,4}$-Dihydroterephthalic (*s*)	835.6
$C_8H_8O_4$	$\Delta^{1,5}$-Dihydroterephthalic (*s*)	842.1
$C_8H_8O_4$	$\Delta^{2,5}$-Dihydroterephthalic (fum.) (*s*)	844.9
$C_8H_{10}O_4$	Δ^1-Tetrahydroterephthalic (*s*)	882
$C_8H_{10}O_4$	Δ^2-Tetrahydroterephthalic (*s*)	881
$C_8H_{12}O_2$	Amylpropiolic	1083
$C_8H_{12}O_2$	Cyclohexene-1-acetic (*s*)	1045
$C_8H_{12}O_2$	Cyclohexylideneacetic (*s*)	1042
$C_8H_{12}O_4$	*trans*-1, 2-Cyclohexanedicarboxylic (*s*)	930
$C_8H_{12}O_4$	*cis*-Hexahydroterephthalic (*s*)	928.2
$C_8H_{12}O_4$	*trans*-Hexahydroterephthalic (*s*)	929.1
$C_8H_{14}O_2$	Cycloheptanecarboxylic (*s*)	1088
$C_8H_{14}O_2$	Cyclooctane (act.)‡	1089.2
$C_8H_{14}O_2$	Hexahydro-*m*-toluic	1086
$C_8H_{14}O_4$	*sym.*-Diethylsuccinic (*s*)	987
$C_8H_{14}O_4$	*unsym.*-Diethylsuccinic (*s*)	985
$C_8H_{14}O_4$	*sym.*-Dimethyladipic (*s*)	986.7
$C_8H_{14}O_4$	Ethylpropylmalonic (*s*)	983
$C_8H_{14}O_4$	Suberic (*s*)	983.4
$C_8H_{14}O_4$	Tetramethylsuccinic (*s*)	989
$C_8H_{14}O_4$	Dimethyldihydroxyadipic (*s*)	889
$C_8H_{16}O_2$	Dipropylacetic	1146
$C_9H_8O_2$	Phenylpropiolic (*s*)	1021
$C_9H_8O_6$	Trimesic (*s*)	767.0
$C_9H_8O_2$	*cis*-Allocinnamic (M. P. 58°) (*s*)	1047
$C_9H_8O_2$	*trans*-Cinnamic (*s*)	1040
$C_9H_8O_2$	Atropic (*s*)	1044
$C_9H_8O_3$	*cis*-(*allo*)-*p*-Hydroxycinnamic (*s*)	996
$C_9H_8O_3$	*trans*-*p*-Hydroxycinnamic (*s*)	991
$C_9H_8O_4$	Uvitic (*s*)	928.3
$C_9H_{10}O_2$	Hydrocinnamic (β-phenylpropionic) (*s*)	1085
$C_9H_{10}O_2$	Mesitylenic (*s*)	1085
$C_9H_{14}O_2$	α-Cyclohexene-1-propionic	1200
$C_9H_{14}O_2$	Hexylpropiolic	1232
$C_9H_{14}O_2$	Campholytic (*s*)	1366
$C_9H_{14}O_2$	Isocampholytic (*s*)	1363

‖ v. p. 162.
¶ Stohmann.
** Auwers and Roth.
†† The numbers denote the positions of carboxyl, hydroxyl and methyl groups respectively.

Formula	Name	kg-cal$_{15}$ per mole
	3. C, H, O, Acids.—(*Continued*)	
$C_9H_{16}O_4$	Azelaic (*s*)	1141.4
$C_9H_{16}O_4$	Dipropylmalonic (*s*)	1140
$C_9H_{18}O_2$	Heptylacetic	1287
$C_{10}H_6O_8$	Pyromellitic (*s*)	776.8
$C_{10}H_8O_4$	*cis*-Allopiperonylacrylic (*s*)	1076
$C_{10}H_8O_4$	*trans*-Piperonylacrylic (*s*)	1067
$C_{10}H_8O_4$	Benzalmalonic (*s*)	1056
$C_{10}H_{10}O_2$	α-Methylcinnamic (*s*)	1198
$C_{10}H_{10}O_2$	β-Methylcinnamic (*s*)	1197
$C_{10}H_{10}O_2$	*cis*-Phenylisocrotonic‡‡ (*s*)	1195
$C_{10}H_{10}O_3$	*cis*-(*allo*)-*p*-Methoxycinnamic (*s*)	1172
$C_{10}H_{10}O_3$	*trans*-*p*-Methoxycinnamic§§ (*s*)	1163
$C_{10}H_{10}O_3$	*cis*-Methylcoumarinic (*s*)	1167
$C_{10}H_{10}O_3$	*trans*-Methylcoumaric (*s*)	1161
$C_{10}H_{10}O_4$	Benzylmalonic (*s*)	1082.5
$C_{10}H_{10}O_4$	Phenylsuccinic (*s*)	1082.8
$C_{10}H_{10}O_5$	Opianic (*s*)	1090
$C_{10}H_{10}O_6$	Hemipinic (*s*)	1025
$C_{10}H_{12}O_2$	Cumic (*p*-isopropylbenzoic) (*s*)	1238
$C_{10}H_{16}O_2$	Geranic	1379
$C_{10}H_{16}O_3$	α-Tanacetoneketocarboxylic (*s*)	1327
$C_{10}H_{16}O_4$	*d*-Camphoric (*s*)	1244
$C_{10}H_{18}O_2$	Campholic (*s*)	1412
$C_{10}H_{18}O_2$	Hexahydrocumic (*s*)	1396
$C_{10}H_{18}O_4$	Heptylmalonic (*s*)	1297
$C_{10}H_{18}O_4$	Sebacic (*s*)	1297
$C_{10}H_{18}O_4$	Triethylsuccinic (*s*)	1301
$C_{10}H_{20}O_2$	Capric (*s*)	1453
$C_{11}H_8O_2$	α-Naphthoic (*s*)	1232
$C_{11}H_8O_2$	β-Naphthoic	1227
$C_{11}H_{10}O_2$	Allocinnamylideneacetic (*s*)	1319
$C_{11}H_{10}O_2$	Cinnamylideneacetic (*s*)	1311
$C_{11}H_{10}O_4$	*cis*-Acetylcoumarinic (*s*)	1212
$C_{11}H_{10}O_4$	*trans*-Acetylcoumaric (*s*)	1208
$C_{11}H_{10}O_4$	Phenylparaconic (*s*)	1195
$C_{11}H_{12}O_3$	*cis*-Ethylcoumarinic (*s*)	1323
$C_{11}H_{12}O_3$	*trans*-Ethylcoumaric (M. P. 133–134°) (*s*)	1316
$C_{11}H_{18}O_2$	Undecolic (*s*)	1538
$C_{11}H_{20}O_2$	Undecylenic (*s*)	1580
$C_{11}H_{20}O_4$	Nonanedicarboxylic (*s*)	1456
$C_{11}H_{20}O_4$	*n*-Octylmalonic (*s*)	1453
$C_{11}H_{22}O_2$	Undecylic (*s*)	1610
$C_{12}H_6O_{12}$	Mellitic (*s*)	788
$C_{12}H_8O_4$	Naphthalic (1, 8-naphthalenedicarboxylic) (*s*)	1244
$C_{12}H_{10}O_4$	Cinnamylidenemalonic (yellow) (*s*)	1319
$C_{12}H_{12}O_3$	β-Benzallevulinic (*s*)	1413
$C_{12}H_{12}O_3$	δ-Benzallevulinic (*s*)	1410
$C_{12}H_{12}O_{12}$	Hexahydromellitic (fum.) (*s*)	923
$C_{12}H_{14}O_3$	*cis*-Propylcoumarinic (*s*)	1476
$C_{12}H_{14}O_3$	*trans*-Propylcoumaric (*s*)	1470
$C_{12}H_{22}O_4$	Decanedicarboxylic (*s*)	1611
$C_{12}H_{22}O_4$	Tetraethylsuccinic (*s*)	1619
$C_{12}H_{24}O_2$	Lauric (*s*)	1772
$C_{13}H_{16}O_3$	*trans*-*n*-Butylcoumaric (*s*)	1631
$C_{13}H_{16}O_3$	*cis*-*n*-Butylcoumarinic (*s*)	1637
$C_{13}H_{24}O_4$	Brassylic (undecanedicarboxylic) (*s*)	1769
$C_{14}H_{12}O_2$	Diphenylacetic (*s*)	1651
$C_{14}H_{12}O_3$	Benzilic (*s*)	1618
$C_{14}H_{18}O_3$	Isoamylcoumaric (*s*)	1790
$C_{14}H_{18}O_3$	*cis*-Isoamylcoumarinic (*s*)	1791
$C_{14}H_{28}O_2$	Myristic (*s*)	2086
$C_{16}H_{14}O_4$	α-Diphenylsuccinic (anhydr.) (easily sol. form) (*s*)‖‖	1810
$C_{16}H_{14}O_4$	β-Diphenylsuccinic (difficultly sol.) (*s*)	1087
$C_{16}H_{16}O_2$	Dibenzylacetic (*s*)	1954
$C_{16}H_{32}O_2$	Palmitic (*s*)	2380
$C_{17}H_{16}O_3$	β-Tolylmethoxycinnamic (stable) (*s*)	2035
$C_{18}H_{16}O_4$	α-Truxillic (*s*)	2083
$C_{18}H_{32}O_2$	Stearolic (*s*)	2629
$C_{18}H_{34}O_2$	Elaidic (*s*)	2664
$C_{18}H_{34}O_2$	Oleic	2657¶¶ 2682***
$C_{18}H_{36}O_2$	Stearic (*s*)	2698
$C_{19}H_{36}O_4$	Cetylmalonic (*s*)	2893
$C_{20}H_{40}O_2$	Arachidic (*s*)	3010
$C_{22}H_{40}O_2$	Behenolic	3255
$C_{22}H_{42}O_2$	Brassidic (*s*)	3290
$C_{22}H_{42}O_2$	Erucic (*s*)	3297
$C_{22}H_{44}O_2$	Behenic (*s*)	3338
$C_{22}H_{44}O_4$	Dihydroxybehenic (*s*)	3236
$C_{24}H_{20}O_5$	Cinnamylidenemalonic†††	2639
	4. C, H, O, Acid Anhydrides and Lactones	
$C_4H_2O_3$	Maleic anhydride (*s*)	333.9
$C_4H_4O_3$	Succinic anhydride (*s*)	369.5
$C_4H_6O_3$	Acetic anhydride (*g*)	458.3
	(liquid)	431.9
$C_5H_4O_3$	Itaconic anhydride (*s*)	481.5
$C_5H_6O_3$	Glutaric anhydride (*s*)	528.0
$C_5H_6O_3$	Methylsuccinic anhydride (*s*)	527.7
$C_6H_8O_3$	Dimethylsuccinic anhydride (*sym.*) (*s*)	680
$C_6H_8O_3$	Dimethylsuccinic anhydride (*unsym.*) (*s*)	682.6
$C_6H_8O_3$	Ethylsuccinic anhydride	684.8
$C_6H_{10}O_3$	Propionic anhydride	746.6
$C_6H_{10}O_5$	Saccharic acid lactone (*s*)	656.6
$C_6H_{10}O_6$	*l*-Gulonolactone (*s*)	614.7
$C_6H_{10}O_6$	*d*-Mannolactone (*s*)	618.7
$C_6H_{10}O_6$	*l*-Mannolactone (*s*)	616.3
$C_7H_{10}O_3$	Trimethylsuccinic anhydride (*s*)	836.1
$C_7H_{10}O_4$	Terebic acid (γ, γ-dimethylparaconic acid) (*s*)	778.3
$C_7H_{12}O_7$	Glucoheptonic acid lactone (*s*)	726.3
$C_8H_4O_3$	Phthalic anhydride (*s*)	781.5
$C_8H_6O_2$	Phthalide (*s*)	884
$C_8H_{10}O_3$	*cis*-Hexahydrophthalic anhydride (sol.) (*s*)	932.0
	trans-Hexahydrophthalic anhydride (sol.) (*s*)	937.8
$C_8H_{12}O_3$	*sym.*-*dl*-Diethylsuccinic anhydride (*s*)	997.6
	anti-Diethylsuccinic anhydride (*s*)	997.2
$C_8H_{12}O_3$	Diethylsuccinic anhydride (*unsym.*) (*s*)	998
$C_8H_{12}O_3$	Tetramethylsuccinic anhydride (*s*)	993
$C_8H_{14}O_8$	Glucooctonic lactone (*s*)	836.7
$C_{10}H_8O_3$	Phenylsuccinic anhydride (*s*)	1094
$C_{10}H_{10}O_4$	Meconine (dimethoxyphthalide)	1137
$C_{10}H_{14}O_3$	Camphoric anhydride (*s*)	1252
$C_{10}H_{16}O_3$	Triethylsuccinic anhydride (*s*)	1310
$C_{11}H_{12}O_5$	4-Methyl opianate (*s*)	1263
$C_{12}H_6O_3$	Naphthalic anhydride (*s*)	1258
$C_{12}H_{20}O_3$	Tetraethylsuccinic anhydride (*s*)	1621
$C_{12}H_{22}O_3$	Diethylacetic anhydride (*s*)	1669
$C_{14}H_{10}O_3$	Benzoic anhydride (*s*)	1555
$C_{14}H_{26}O_3$	Heptylic anhydride (*s*)	1985
$C_{16}H_{10}O_3$	Diphenylmaleic anhydride	1769
$C_{16}H_{12}O_3$	*dl*-Diphenylsuccinic anhydride (*s*)	1816
$C_{18}H_{14}O_3$	Cinnamic anhydride (*s*)	2091
$C_{28}H_{22}O_3$	Diphenylacetic anhydride (*s*)	3308
$C_{32}H_{30}O_3$	Dibenzylacetic anhydride (glassy) (*s*)	3931
	5. C, H, O, Carbohydrates: Cellulose, Starch, Etc.	
$C_5H_{10}O_5$	Arabinose (*s*)	559
$C_5H_{10}O_5$	Xylose (*s*)	561
$C_6H_{10}O_5$	*l*-Glucosan (*s*)	678
$C_6H_{12}O_5$	Fucose (*s*)	712
$C_6H_{12}O_5$	Rhamnose (*s*)	718
$C_6H_{12}O_5$	Rhamnose (*s*)	711.5
$C_6H_{12}O_6$	Galactose (*s*)	670
$C_6H_{12}O_6$	*d*-Glucose (dextrose)	673
$C_6H_{12}O_6$	*l*-Fructose (*s*)	675
$C_6H_{12}O_6$	Sorbinose (*d*-sorbose) (*s*)	668
$C_7H_{14}O_7$	Glucoheptose (*s*)	783.5
$C_{12}H_{18}O_8$	Rhamnose triacetate (*s*)	1351
$C_{12}H_{22}O_{11}$	Cellobiose (anhydr.) (*s*)	1350
$C_{12}H_{22}O_{11}$	Lactose (anhydr.) (*s*)	1350.8
$C_{12}H_{22}O_{11}.H_2O$	Lactose (*s*)	1344.7
$C_{12}H_{22}O_{11}$	Maltose (*s*)	1350.6
$C_{12}H_{22}O_{11}.H_2O$	Maltose (cryst.)	1339.2
$C_{12}H_{22}O_{11}$	Sucrose (*s*)*	1349.6
$C_{12}H_{22}O_{11}$	Trehalose (cryst.)	1341.5
$C_{12}H_{22}O_{11}$	Trehalose (mycose) (*s*)	1349.4
$C_{12}H_{22}O_{11}$	Galactose pentaacetate (*s*)	1726
$C_{12}H_{22}O_{11}$	Glucose pentaacetate (*s*)	1726
$C_{18}H_{32}O_{16}.H_2O$	Melezitose (*s*)	2042

‡‡ $C_6H_5.CH{:}CH.CH_2COOH$.

§§ M. P. 170° (liq. cryst.); clears at 185°.

‖‖ The heat of combustion of the acetone addition product of α-diphenylsuccinic acid (easily sol. form) is given as 2237.9 kg-cal.

¶¶ Emery and Benedict.

*** Stohmann.

††† Exposed to the action of light.

* *v.* p. 162.

Formula	Name	kg-cal$_{15}$ per mole
$C_{18}H_{32}O_{16}$	Raffinose (melitose) (*s*)	2025.5
$C_{18}H_{32}O_{16}.5H_2O$	Raffinose (cryst.)	2018.9
$C_{18}H_{32}O_{16}$	Stachyose (anhyd.) (calc.) (*s*)	2709
$C_{28}H_{38}O_{19}$	Cellobiose octoacetate (*s*)	3032.6
$C_{28}H_{38}O_{19}$	Lactose octoacetate (*s*)	3029.8
$C_{28}H_{38}O_{19}$	Maltose octoacetate (*s*)	3030.6
$C_{28}H_{38}O_{19}$	Sucrose octoacetate (*s*)	3033.8

Name	g-cal$_{15}$ per gram
Starch	4179
Starch acetate	4499
Inulin	4130
Inulin acetate	4190
Dextrin	4522
Glycogen	4110
Cellulose	4186.8
Cellulose acetate	4181
Xylan	4496
Xylan acetate	4260
	4548

6. Other C, H, O-Compounds (partial list only; for complete list, *v.* [1])

Formula	Name	kg-cal$_{15}$ per mole
CH_2O	Formaldehyde (*g*)	134
$1/n\ (CH_2O)_n$	Paraformaldehyde (*s*)	122
C_2H_4O	Acetaldehyde (*g*)	280.5
$C_2H_4O_2$	Methyl formate (*g*)	279.0
	(liquid)	240.2
C_2H_6O	Dimethyl ether (*g*)	233.1
C_3H_6O	Acetone	347.6
$C_3H_6O_2$	Ethyl formate (*g*)	427
	(liquid)	398.4
$C_3H_6O_2$	Methyl acetate (*g*)	391.7
	(liquid)	397.7
C_3H_8O	Methyl ethyl ether (*g*)	381.2
$C_3H_8O_2$	Methylal	503.4
C_4H_8O	Methyl ethyl ketone	462.8
$C_4H_8O_2$	Ethyl acetate (*g*)	582
	(liquid)	544.4
$C_4H_8O_2$	Methyl propionate (*g*)	538.5
$C_4H_{10}O$	Diethyl ether (*g*)	552.3
	(liquid)	660.3
$C_5H_{10}O$	Diethyl ketone	651.7
$C_5H_{10}O$	Methyl propyl ketone	736
$C_5H_{10}O$	Methyl isopropyl ketone	736
$C_5H_{10}O_2$	Ethyl propionate	734
$C_6H_4O_2$	Quinone (*s*)	690.8
C_6H_6O	Phenol (*s*)	656.5
$C_6H_6O_2$	Pyrocatechol (*s*)	732
$C_6H_6O_2$	Resorcinol (*s*)	685
$C_6H_6O_2$	Hydroquinol (*s*)	683
$C_6H_6O_3$	Pyrogallol (*s*)	683
$C_6H_{10}O_3$	Ethyl acetoacetate	639
$C_6H_{12}O_2$	Ethyl *n*-butyrate	753.6
$C_6H_{12}O_2$	Ethyl isobutyrate	851.2
$C_7H_{14}O$	Dipropyl ketone	845.7
$C_7H_{14}O_2$	Amyl acetate	1051
$C_7H_{14}O_2$	Ethyl valerate	1040
C_8H_8O	Acetophenone (*s*)	1017
$C_8H_8O_2$	Methyl benzoate	989
$C_8H_8O_3$	Methyl salicylate	943.5
$C_8H_{16}O$	Methyl hexyl ketone	898.8
$C_9H_{10}O_2$	Ethyl benzoate	1205
$C_9H_{10}O_3$	Ethyl *p*-hydroxybenzoate (*s*)	1099
$C_9H_{10}O_3$	Ethyl salicylate	1043
$C_{10}H_8O$	α-Naphthol (*s*)	1051
$C_{10}H_8O$	β-Naphthol (*s*)	1185
$C_{10}H_{16}O$	Camphor (*s*)	1187
$C_{13}H_{10}O$	Benzophenone (*s*)	1411
$C_{14}H_8O_2$	Anthraquinone (*s*)	1557
		1545

7. Nitrogen Compounds (partial list only; for complete list, *v.* [1])

CH_3NO	Formamide	135
CH_3NO_2	Nitromethane	169.4
CH_4N_2O	Urea (*s*)	152
CH_5N	Methylamine (*g*)	259
	(liquid)	256
C_2N_2	Cyanogen (*g*)	260
C_2H_3N	Acetonitrile (*g*)	310.4
	(liquid)	302.4
C_2H_3NO	Glycolic nitrile	256.7
C_2H_3NO	Methyl isocyanate	269.4
$C_2H_3NO_3$	Oxamic acid (*s*)	130
$C_2H_4N_2O_2$	Oxamide (*s*)	203
C_2H_5NO	Acetamide (*s*)	283
$C_2H_5NO_2$	Nitroethane	322.2
$C_2H_5NO_2$	Ethyl nitrite (*g*)	333
$C_2H_5NO_2$	Glycine (aminoacetic acid) (*s*)	234
$C_2H_5NO_3$	Ethyl nitrate (*g*)	322
C_2H_7N	Dimethylamine (*g*)	422
	(liquid)	417
C_2H_7N	Ethylamine (*g*)	413
	(liquid)	408.5
$C_2H_8N_2.H_2O$	Ethylenediamine	452.6
$C_3H_2N_2$	Malononitrile (*s*)	394.8
$C_3H_2N_2O_3$	Parabanic acid (*s*)	212.4
$C_3H_4N_2O_2$	Hydantoin (*s*)	311.7
C_3H_5N	Propionitrile	456.4
C_3H_5NO	Ethyl isocyanate	424.5
$C_3H_5N_3O_9$	Trinitroglycerol	432.4
$C_3H_6N_2O_2$	Malonamide (*s*)	359
$C_3H_6N_2O_3$	Hydantoic acid (*s*)	308.6
C_3H_7N	Allylamine (*g*)	528.1
	(liquid)	524.8
C_3H_7NO	Propionamide (*s*)	440
$C_3H_7NO_2$	Alanine (*s*)	388.5
$C_3H_7NO_2$	*d*-Alanine (*s*)	387.5
$C_3H_7NO_2$	Nitropropane	477.9
$C_3H_7NO_2$	Sarcosine (*s*)	401
$C_3H_7NO_2$	Urethane (*s*)	397
$C_3H_7NO_3$	Isoserine (*s*)	343.7
$C_3H_8N_2O$	Ethylurea (*s*)	472
C_3H_9N	Propylamine (*g*)	572.3
	(liquid)	558.3
C_3H_9N	Trimethylamine	578.6
C_4N_2	Carbon subnitride (acetylenedicarboxylic acid nitrile) (*s*)	515
$C_4H_2N_2O_4.H_2O$	Alloxan (*s*)	276.3
C_4H_3N	Allyl cyanide	575
C_4H_3N	Trimethylene nitrile	581
C_4H_3N	Pyrrole	567.7
$C_4H_4NO_2$	Succinimide (*s*)	438
$C_4H_6N_2O_2$	Diketopiperazine (*s*)	474.6
C_4H_7N	*n*-Butyronitrile	613.3
$C_4H_7NO_4$	Aspartic acid (*s*)	384.9
$C_4H_7N_3O$	Creatinine (*s*)	563.4
$C_4H_8N_2O_2$	Succinamide (*s*)	509.2
$C_4H_8N_2O_3$	Asparagine (*s*)	463.3
$C_4H_8N_2O_3.H_2O$	Asparagine (cryst.)	459.7
C_4H_9NO	*n*-Butyramide (*s*)	596.0
C_4H_9NO	Isobutyramide (*s*)	596.0
$C_4H_9NO_2$	Isobutyl nitrite (*g*)	644.6
$C_4H_9N_3O_2$	Creatine (anhydr.) (*s*)	558
$C_4H_9N_3O_2.H_2O$	Creatine (cryst.)	553.1
$C_4H_{11}N$	*n*-Butylamine	710.6
$C_4H_{11}N$	Isobutylamine	713.6
$C_4H_{11}N$	*sec.*-Butylamine	713
$C_4H_{11}N$	*tert.*-Butylamine	716
$C_4H_{11}N$	Diethylamine (*g*)	731
	(liquid)	722.8
$C_5H_4N_4O_3$	Uric acid (*s*)	460.2
C_5H_5N	Pyridine	660
$C_5H_5N_5O$	Guanine (*s*)	586
$C_5H_6N_2O_2$	4-Methyluracil (*s*)	566
$C_5H_6N_2O_2$	5-Methyluracil (*s*)	565
$C_5H_6N_4O_4$	Pseudouric acid (*s*)	454.2
$C_5H_8N_2O_2$	4-Methylhydrouracil (*s*)	618
$C_5H_9NO_4$	Glutamic acid (act.) (*s*)	542.4
$C_5H_{11}N$	Piperidine	826.6
$C_5H_{11}NO_2$	*d-l*-α-Aminoisovaleric acid (*s*)	701
$C_5H_{13}N$	Isoamylamine	867
$C_6H_3N_3O_6$	1, 2, 4-Trinitrobenzene (*s*)	674
$C_6H_3N_3O_6$	1, 3, 5-Trinitrobenzene (*s*)	664
$C_6H_3N_3O_7$	2, 4, 6-Trinitrophenol (*s*)	620
$C_6H_4N_2O_4$	*o*-Dinitrobenzene (*s*)	703.2

Formula	Name	kg-cal$_{15}$ per mole
	7. Nitrogen Compounds.—(*Continued*)	
$C_6H_4N_2O_4$	*m*-Dinitrobenzene (*s*)	697
$C_6H_4N_2O_4$	*p*-Dinitrobenzene (*s*)	695
$C_6H_4N_2O_5$	2, 4-Dinitrophenol (*s*)	648
$C_6H_5NO_2$	Nitrobenzene	739
$C_6H_5NO_3$	*o*-Nitrophenol (*s*)	689
$C_6H_5NO_3$	*m*-Nitrophenol (*s*)	684
$C_6H_5NO_3$	*p*-Nitrophenol (*s*)	686
$C_6H_6N_2O_2$	*o*-Nitroaniline (*s*)	766
$C_6H_6N_2O_2$	*m*-Nitroaniline (*s*)	765
$C_6H_6N_2O_2$	*p*-Nitroaniline (*s*)	761
$C_6H_6N_2O_3$	*m*-Nitrophenylhydroxylamine	766
C_6H_7N	Aniline	812
C_6H_7N	α-Picoline	815
C_6H_7N	β-Picoline	812
C_6H_7N	γ-Picoline	816
C_6H_7NO	Phenylhydroxylamine	804
$C_6H_8N_2$	Phenylhydrazine (*s*)	875
		805
$C_6H_8N_2$	*p*-Phenylenediamine (*s*)	843
$C_6H_{12}N_2O_3$	*d*-Alanine anhydride (*s*)	786
$C_6H_{12}N_4$	Hexamethylenetetramine (*s*)	1006.7
$C_6H_{13}NO_2$	Leucine (*s*)	856
$C_6H_{15}N$	Hexylamine	1022
$C_6H_{15}N$	Triethylamine	1037
C_7H_5N	Benzonitrile	866
$C_7H_5NO_3$	*m*-Nitrobenzaldehyde (*s*)	800
$C_7H_5NO_4$	*o*-Nitrobenzoic acid (*s*)	735
$C_7H_5NO_4$	*m*-Nitrobenzoic acid (*s*)	729
$C_7H_5NO_4$	*p*-Nitrobenzoic acid (*s*)	728
$C_7H_5N_3O_6$	2, 3, 4-Trinitrotoluene	833
$C_7H_5N_3O_6$	2, 3, 5-Trinitrotoluene (*s*)	824
$C_7H_5N_3O_6$	?, 3, 5-Trinitrotoluene	825
$C_7H_5N_3O_6$	2, 4, 6-Trinitrotoluene (*s*)	821
$C_7H_5N_3O_6$	3, 4, 5-Trinitrotoluene (*s*)	828
$C_7H_5N_3O_6$	3, 4, 6-Trinitrotoluene (*s*)	826
$C_7H_5N_5O_8$	Tetryl (*s*)	842
$C_7H_6N_2O_4$	2, 3-Dinitrotoluene (*s*)	859
$C_7H_6N_2O_4$	2, 4-Dinitrotoluene (*s*)	853
$C_7H_6N_2O_4$	2, 5-Dinitrotoluene (*s*)	855
$C_7H_6N_2O_4$	2, 6-Dinitrotoluene (*s*)	854
$C_7H_6N_2O_4$	3, 4-Dinitrotoluene (*s*)	860
$C_7H_6N_2O_4$	3, 5-Dinitrotoluene (*s*)	853
C_7H_7NO	Benzamide (*s*)	848
C_7H_7NO	Formanilide (*s*)	861
$C_7H_7NO_2$	*o*-Nitrotoluene	897
$C_7H_7NO_2$	*m*-Nitrotoluene	893
$C_7H_7NO_2$	*p*-Nitrotoluene (*s*)	889
$C_7H_7N_3O_4$	2, 4-Dinitromethylaniline (*s*)	884.5
$C_7H_8N_2O_2$	*p*-Nitromethylaniline (*s*)	924
$C_7H_8N_4O_2$	Theobromine (*s*)	845
C_7H_9N	Benzylamine	967
C_7H_9N	Methylaniline	973.5
C_7H_9N	*o*-Toluidine	964
C_7H_9N	*m*-Toluidine	965
C_7H_9N	*p*-Toluidine	958
$C_7H_{17}N$	Heptylamine	1179
C_8H_5NO	Benzoyl cyanide (*s*)	940
$C_8H_5NO_2$	Isatin (*s*)	868
$C_8H_5NO_2$	Phthalimide (*s*)	850
C_8H_7N	Benzyl cyanide	1024
C_8H_7N	Indole (*s*)	1022
$C_8H_7NO_2$	Dioxindol (*s*)	916
$C_8H_7N_5O_8$	Methyltetryl (*s*)	1009
$C_8H_8N_2O_3$	*o*-Nitroacetanilide (*s*)	974
$C_8H_8N_2O_3$	*m*-Nitroacetanilide (*s*)	970
$C_8H_8N_2O_3$	*p*-Nitroacetanilide (*s*)	968
C_8H_9NO	Acetanilide (*s*)	1010
$C_8H_9NO_2$	Phenylglycine (phenylaminoacetic acid) (*s*)	955
$C_8H_9NO_3$	*o*-Nitrophenetole	1021
$C_8H_9NO_3$	*m*-Nitrophenetole	1009
$C_8H_9NO_3$	*p*-Nitrophenetole	1006
$C_8H_{10}N_4O_2$	Caffeine (*s*)	1014
$C_8H_{11}N$	Dimethylaniline	1143
$C_8H_{11}N$	Ethylaniline	1122
$C_8H_{12}N_2O$	Veronal (5,5-diethylbarbituric acid) (*s*)	983
$C_8H_{17}N$	Coniine	1275
$C_8H_{19}N$	Diisobutylamine	1348
C_9H_7N	Quinoline	1123
C_9H_9N	3-Methylindole	1170
C_9H_9N	α-Methylindole	1169
$C_9H_9NO_3$	Hippuric acid (*s*)	1012
$C_9H_{11}NO$	Propionanilide (*s*)	1168
$C_9H_{11}NO_2$	Phenylalanine (*s*)	1111
$C_9H_{11}NO_3$	Tyrosine (*s*)	1070
$C_9H_{13}N$	Benzylethylamine	1290
$C_{10}H_9N$	α-Naphthylamine (*s*)	1264
$C_{10}H_9N$	β-Naphthylamine (*s*)	1261
$C_{10}H_9NO_4$	Hemipinimide (*s*)	1099
$C_{10}H_{13}N$	Tetrahydroquinaldine	1382
$C_{10}H_{13}NO_2$	Phenacetin (*s*)	1285
$C_{10}H_{14}N_2$	Nicotine	1428
$C_{10}H_{15}N$	Diethylaniline	1452
$C_{10}H_{23}N$	Diisoamylamine	1660
$C_{11}H_7N$	α-Naphthonitrile (*s*)	1326
$C_{11}H_7N$	β-Naphthonitrile (*s*)	1321
$C_{12}H_9N$	Carbazole (*s*)	1475
$C_{12}H_{10}N_2$	Azobenzene (*s*)	1546
$C_{12}H_{11}N$	Diphenylamine (*s*)	1538
$C_{12}H_{12}N_2$	Hydrazobenzene (*s*)	1597
		1599
$C_{12}H_{12}N_2$	Benzidine (*s*)	1561
$C_{12}H_{27}N$	Triisobutylamine	1974
$C_{13}H_{11}NO$	Benzanilide (*s*)	1576
$C_{13}H_{12}N_2O$	*sym.*-Diphenylurea (*s*)	1612
$C_{13}H_{12}N_2O$	*unsym.*-Diphenylurea (*s*)	1614
$C_{14}H_{15}N$	Dibenzylamine (*s*)	1853
$C_{15}H_{33}N$	Triisoamylamine	2459
$C_{16}H_{10}N_2O_2$	Indigo (*s*)	1815
$C_{16}H_{13}N$	Phenyl-α-naphthylamine (*s*)	2004
$C_{16}H_{13}N$	Phenyl-β-naphthylamine (*s*)	1998
$C_{17}H_{19}NO_3.H_2O$	Morphine (*s*)	2146
$C_{18}H_{15}N$	Triphenylamine (*s*)	2268
$C_{18}H_{21}NO_3.H_2O$	Codeine (*s*)	2328
$C_{19}H_{21}NO_3$	Thebaine (*s*)	2441
$C_{20}H_{21}NO_4$	Papaverine (*s*)	2478
$C_{20}H_{27}NO_{11}$	Amygdalin (*s*)	2348
$C_{21}H_{21}N$	Tribenzylamine (*s*)	2762
$C_{21}H_{22}N_2O_2$	Strychnine (*s*)	2686
$C_{22}H_{23}NO_7$	Narcotine (*s*)	1644
$C_{23}H_{26}N_2O_4$	Brucine (*s*)	2933
$C_{23}H_{27}NO_3.2H_2O$	Narceine (*s*)	2803

8. Halogen Compounds (partial list only; for complete list, *v.* (1)). Final states: dil. solution of HCl; Br vapor; solid I_2

CCl_4	Carbon tetrachloride (*g*)	44.5
	(liquid)	37.3
$CHCl_3$	Chloroform (*g*)	70.3
	(liquid)	89.2
CHI_3	Iodoform (*s*)	162
CH_2Cl_2	Methylene chloride (*g*)	106.8*
CH_2I_2	Methylene iodide	178
CH_3Br	Methyl bromide (*g*)	184
		180
CH_3Cl	Methyl chloride	164
		173
CH_3I	Methyl iodide (*g*)	200.5
	(liquid)	194.7
$C_2HCl_3O_2$	Trichloroacetic acid (*s*)	92.8
C_2H_3ClO	Chloroacetaldehyde	234.4
$C_2H_3ClO_2$	Chloroacetic acid (*s*)	171.0
$C_2H_4Cl_2$	Ethylene chloride (*g*)	271.0
$C_2H_4Cl_2$	Ethylidene chloride (*g*)	271.1
	(liquid)	267.1*
C_2H_5Br	Ethyl bromide (*g*)	340
		329
C_2H_5Cl	Ethyl chloride (*g*)	316.7
		326.9
C_2H_5I	Ethyl iodide (*g*)	358
	(liquid)	356
C_3H_5Cl	Allyl chloride (*g*)	440.8
C_3H_7Br	Propyl bromide (*g*)	497
C_3H_7Cl	Propyl chloride (*g*)	478.3
C_3H_7I	*n*-Propyl iodide	514.3
C_3H_7I	Isopropyl iodide	509.1
$C_4H_6Cl_2O_2$	Ethyl dichloroacetate	463.4

* HCl gas.

Formula	Name	kg-cal$_{15}$ per mole
$C_4H_7ClO_2$	Ethyl chloroacetate	493.9
C_4H_9Cl	Isobutyl chloride	635.5
$C_6Cl_4O_2$	Tetrachloroquinone (*s*)	517.7
$C_6HCl_3O_2$	Trichloroquinone (*s*)	546.4
$C_6H_2Cl_2O_2$	2, 6-Dichloroquinone (*s*)	578.9
$C_6H_2Cl_2O_4$	Chloroanilic acid (*s*)	484.9
$C_6H_2Cl_4O_2$	Tetrachlorohydroquinol (*s*)	563
$C_6H_3ClO_2$	Chloroquinone (*s*)	616.6
$C_6H_3Cl_3O_2$	Trichlorohydroquinol (*s*)	593
$C_6H_4Cl_2$	*o*-Dichlorobenzene (*s*)	671.8
$C_6H_4Cl_2O_2$	2, 6-Dichlorohydroquinol (*s*)	614
$C_6H_5ClO_2$	Chlorohydroquinol (*s*)	646
C_6H_5I	Phenyl iodide	771
C_7H_5ClO	Benzoyl chloride	783
C_7H_7Cl	Benzyl chloride	886.4
$C_8H_4Cl_2O_2$	Phthalyl chloride (*s*)	802

9. SULFUR COMPOUNDS, final state: dilute H_2SO_4 aq., except as otherwise noted

COS	Carbonyl sulfide (*g*)	130.5*
CS_2	Carbon disulfide	246.6*
CH_4N_2S	Thiourea (*s*)	342.8†
CH_4S	Methylmercaptan (*g*)	297.6*
C_2H_3NS	Methyl thiocyanate (*g*)	397.4*
	(liquid)	453.1
C_2H_3NS	Methyl isothiocyanate (*g*)	390.5*
	(*s*)	442.9
C_2H_6S	Dimethyl sulfide (*g*)	455.6*
C_2H_6S	Ethylmercaptan (*g*)	452.0*
	(liquid)	517.2
$C_2H_7NO_3S$	Taurine (*s*)	382.9
$C_3H_4N_2OS$	Thiohydantoin (*s*)	503.0
C_3H_3NS	Ethyl thiocyanate	613.8
C_3H_5NS	Ethyl isothiocyanate	604.1
$C_3H_6N_2O_2S$	Thiohydantoic acid (*s*)	498.5
C_4H_4S	Thiophene (liquid)	670.5
	(*g*)	608.2
C_4H_5NS	Allyl mustard oil (liquid)	733
	(*g*)	673*
$C_4H_8N_2S$	Allythiourea (*s*)	792
$C_4H_9NS_2$	Dimethyl *N*-methylcarbimidedithiolate	969
$C_4H_9NS_2$	*S*-Methyl *N*-dimethyldithiocarbamate (sol.)	954
$C_4H_9NS_2$	Methyl formothialdine	964.5
$C_4H_{10}S$	Diethyl sulfide (*g*)	769*
	(liquid)	829
$C_5H_4O_2S$	α-Thiophenecarboxylic acid (*s*)	646
$C_5H_5O_2S$	Tetrahydro-α-thiophenecarboxylic acid (*s*)	755
$C_5H_{10}N_2S_2$	Dimethyl formocarbothialdine (sol.)	1098
$C_5H_{10}N_2S_2$	Carbothialdine (sol.)	1086
$C_5H_{10}N_2S_2$	Pentamethylenediamine disulfine (sol.)	1113
$C_5H_{11}NS_2$	*S*-Ethyl *N*-dimethyldithiocarbamate	1122
$C_5H_{11}NS_2$	Dimethyl *N*-ethylcarbimidedithiolate	1130
$C_6H_{12}N_2O_4S_2$	Cystine (*s*)	994*
$C_6H_{13}NS_2$	*S*-Methyl *N*-diethyldithiocarbamate	1272
$C_6H_{13}NS_2$	Diethyl *N*-methylcarbimidedithiolate	1289
$C_6H_{13}NS_2$	Thialdine (sol.)	1264
C_7H_5NS	Phenyl isothiocyanate	1024
$C_9H_{11}NS_2$	Dimethyl *N*-phenylcarbimidedithiolate	1545
$C_{18}H_{14}N_2O_2S$	Benzonaphthoquinonethiazine (*s*)	2278

* Gaseous SO_2. † $H_2SO_4.200H_2O$.

LITERATURE

(For a key to the periodicals see end of volume)

(1) Kharasch, *546*: **2**: 359; 29. (2) Schläpfer and Fioroni, *37*, **6**: 713; 23. (3) Swietoslawski, *42*, **22**: 583; 25. (4) Verkade and Coops, *70*, **42**: 205; 23. (5) Verkade and Coops, *7*, **118**: 123; 25.

THERMOCHEMISTRY: HEATS OF FORMATION UNDER CONSTANT PRESSURE (HEATS OF SOLUTION. HEATS OF TRANSITION)

F. RUSSELL BICHOWSKY

EXPLANATION

Arrangement.—Standard, *v.* Vol. III, p. viii.

Column 1. *Formula.*—The formula appearing in Column 1 identifies the substance whose heat of formation per g.f.w. (gram-formula-weight) is shown in Column 3. Polymorphic forms or states requiring further description than that given in Column 2 are indicated by arbitrary signs in parentheses; *e.g.*, by Greek letters, Roman numerals, or descriptive phrases. The polymorphic forms are further identified by the transition temperature given in Column 4 as superscript after the abbreviation, Tr.

Column 2. *Physical State.*—For each substance the physical state to which the heat of formation refers is indicated in Column 2. *See* list of abbreviations below. All states are for 1 atm. and 18°C, unless otherwise indicated by superscript in Column 3. Numerals or formulae in Column 2 indicate that the substance is in solution, one g.f.w. being dissolved in *X* g.f.w. of the solvent. Where the solvent is not explicitly stated, water is to be understood. Where the solvent is given but the concentration not stated, the solution is "dilute." Thus, 200 = "1 g.f.w. of the substance (Column 2) dissolved in 200 × 18 g H_2O;" $200_{C_2H_5OH}$ = "1 g.f.w. of the substance dissolved in 200 × 46.0 g C_2H_5OH;" CS_2 = "1 g.f.w. of the substance dissolved in a large amount of CS_2," etc.

Column 3. *Heat of Formation.*—The values in Column 3 are the number of kilojoules, kj (absolute), of heat *evolved* when one g.f.w. of the substance (shown in Column 1), in the state given in Column 2, is produced out of its elements, in their standard states, at 18° and 1 atm. According to the above definition the heat of formation of an element in its standard state is zero. The standard state of any element may be located by this fact and by the abbreviation "Def." in Column 3 opposite the formula of the element. Heats of formation of ions are based on the arbitrary value, 0, for H^+, and are for dilute solutions of completely ionized electrolytes.

Accuracy.—All the values recorded in this table have been recomputed from the original experimental data, using consistent values for all subsidiary quantities. Heats of reactions and of dilution may therefore be computed by difference with an accuracy as high as known. Estimated accuracy is indicated by number of significant figures. This accuracy is not the absolute accuracy, but the accuracy of the particular reaction used to compute the figure given (*v.* Column 4). The absolute accuracy will be less than that of the least accurate determination in the total chain of reactions used to calculate the heat of formation from the elements.

Column 4. *Method.*—In Column 4 an attempt has been made to indicate in a general way the reactions which have been employed in computing the values given. *See* list of abbreviations below. Formulae in this column, *e.g.*, MOH, indicate that the heat of formation of M^+ depends on the value in the table for the heat of formation of dilute MOH solution. Numerals in this column, *e.g.*, 3.65, not preceded by the abbreviation Tr., indicate the experimentally determined heat of solution, on which the value in Column 4 is based, *e.g.*, 3.65 kj. Numerals in this column following the sign, Tr., *e.g.*, Tr. 0.8, indicate the experimentally determined heat of transition, *e.g.*, 0.8 kj. Superscripts indicate the temperature at which the reaction was measured.

Column 5. *Literature References.*—References are to the original publication, except in the case of Thomsen, where values

are usually quoted from his book. Where the method used by the author is non-calorimetric, *e.g.*, temperature coefficient of EMF, etc., the reference is starred. If the reference contains values determined at other temperatures, it is followed by the symbol, °. If it contains values for the partial heat of solution or other "partial" thermal quantities, the reference is followed by the symbol, †. By partial thermal quantities is meant $\frac{\partial \Delta Q}{\partial N_1}$, where N_1 is the concentration of the substance, 1, in any units, usually mole fractions.

Computations

To compute the heat of any process involving the disappearance of a substance or substances in the states given in the table and the appearance of other or the same substances in states given in the table: Add together the heats of formation of the products of the process in the final states and subtract therefrom the sum of the heats of formation of the reactants in their initial states. Thus:

Heat of Reaction.—CaO (crys.) + H_2O (liq.) = $Ca(OH)_2$ (crys.), $\Delta Q = Q Ca(OH)_2 - [Q CaO + Q H_2O] = 988 - [634.9 + 286.2] = 66.9$ kj.

Heat of Solution.—If a direct experimental determination is available, it will be found in Column 3 in the form 8.66^{18}_{400} which indicates that the heat of solution of one g.f.w. of the substance in 400 moles of H_2O at 18° is 8.66 kj. When the temperature or dilution is not indicated, the precise value is not given in the original, and the value is for "room temperature" and for a "dilute" solution. If the heat of solution is not directly given in Column 4 it may be found by writing the reaction and proceeding as with heats of reaction above. For example, to find the heat of solution of $SrCl_2.2H_2O$ in 400 moles of water, write: $SrCl_2.2H_2O = SrCl_{2(400)} + 2H_2O$; $\Delta Q = 874.7 + 2 \times 286.2 - 1438.4 = 8.7$ kj.

Heat of Dilution.—The molal integral heat of dilution, *i.e.*, the heat of diluting, with y moles of H_2O, a solution of one g.f.w. of the substance in x moles of H_2O is the excess of the heat of formation of 1 g.f.w. of the substance in the final solution over its heat of formation in the initial solution. Thus: The heat of diluting one mole of H_2SO_4 in 99 moles of water to one mole of H_2SO_4 in 799 moles of water is 871.6 − 867.8 = 3.8 kj.

Heat of Transition.—If both forms of the substance can be obtained at 18° and one atmosphere, subtract the heat of formation of the final form from that of the initial form. For transitions which can be realized under 1 atm. only at temperatures other than 18°, the heat of transition will be found in Column 3 after the abbreviation, Tr. For example, the heat of transition from Mn_α to Mn_β is given in the form Mn_α . . . Tr.; 5.5_β^{1100} which means that 5.5 kj of heat is evolved when one gram-atomic-weight of α-manganese changes to β-manganese at 1100°.

Heats of Ionization.—The heat of formation of a completely ionized solution of a substance can be considered as the sum of the heats of formation of its ions. Therefore, if the heat of formation of a completely ionized solution is known, and that of all but one of its ions is known the heat of formation of the other ion may be calculated. This method has been used in calculating the heats of formation of ions given in the table, the heat of formation of H^+ being arbitrarily taken as zero. Conversely, knowing heats of formation of the ions, the heat of formation of a dilute solution of a strong electrolyte may be found by addition of the heats of formation of its ions; *e.g.*, the heat of formation of $(NH_4)_2SeO_4$ (aq.) = $2Q NH_4^+ + Q SeO_4^= = 2 \times 132.7 + 613 = 878.4$ kj. Similarly, the heat of ionization of a weak electrolyte may be computed by summing the heats of formation of its ions and subtracting therefrom its heat of formation; *e.g.*, $H_2O = OH^- + H^+$; $\Delta Q = Q OH^- + Q H^+ - Q H_2O = 228.2 + 0 - 286.2 = -58.0$ kj.

ABBREVIATIONS, SIGNS AND FORMS

Abbreviations

amorp.	Amorphous, crytocrystalline or ill defined solid state.
aq.	Dilute aqueous solution.
c	Macrocrystalline.
coll.	Colloidal gel or sol.
Def.	Standard state.
dil.	Depends upon a heat of dilution.
dissoc.	Depends upon a heat of dissociation.
extrap.	Extrapolated.
gls.	A glass or solid supercooled liquid.
(ideal)	In the condition indicated by the formula, *e.g.*, for N_2O_4 the word "(ideal)" in Column 2 indicates that the heat of formation is for a gas composed of N_2O_4 molecules only.
liq.	Liquid.
mix.	Heat of mixing.
N	From heat of neutralization.
ppt.	Precipitated or from heat of precipitation.
sat.	In saturated solution in H_2O.

Signs

In the Table

*	By indirect non-calorimetric methods.
&	By several different methods.
∞	In an infinite amount of H_2O unless otherwise indicated.

In the Literature Reference Column

*	By indirect non-calorimetric methods.
†	Includes determination or compilation of "partial" quantities.
°	Includes determinations at temperatures other than 18°.

Forms

$+X_2$	Deduced from heat of reaction with X_2.
Tr.; $0.92^{427}_{(i)}$	The heat of transition to crystalline form "I" is 0.92 kj at 427°.

Superscripts

2600^{35}	A superscript indicates the temperature.

Subscripts

365_{100}	The dilution of the final solution is 100 moles of H_2O per gram-formula-weight of substance.
365_{KOH}	In a dilute KOH solution.
$365_{KOH(100)}$	The solvent is one mole KOH to 100 moles H_2O.
365_{24KCN}	The solvent is a solution containing 24 moles of KCN per mole solute.

Illustrative Examples

H_2O.—The information given in Columns 2 and 3 is equivalent to the following: "When two atomic weights (2.0154 g) of hydrogen gas (H_2) at 18° and 1 atm. react with one atomic weight (16.00 g) of oxygen gas at 18° and 1 atm. to produce one g.f.w. (18.0154 g) of liquid H_2O at 18° and one atm., 286.2 kj of heat are evolved." This is equivalent (*see* conversion factors given below) to $0.23895 \times 286.2 = 68.39$ kg-cal_{15} and to $0.94823 \times 286.2 = 270.4$ BTU_{60}; it is also equivalent to $\frac{0.94823 \times 286.2}{18.0154} \times 453.59243 = 6831$ BTU_{60} per lb. of H_2O produced or to $\frac{0.94823 \times 286.2}{16.0} \times 453.59423 = 7693$ BTU_{60} per lb. O_2 consumed.

Cl^-.—The information given in Columns 2, 3 and 4 is equivalent to the following: "The heat of formation of a completely ionized

solution containing one g.f.w. (35.458 g) of Cl^- and the equivalent amount of some positive ion (*e.g.*, a solution of $Cl^- + H^+ = HCl_\infty$) is the sum of the heat of formation of Cl^-, $Q = 165.55$, and of H^+, $Q = 0$, which is $Q = 165.55$ kj."

$H_2O_{2(200)}$.—The information given in Columns 2 and 3 is equivalent to the following: "When two gram-atomic-weights (2×1.0077 g) of hydrogen gas at 18° and 1 atm. react with two gram-atomic-weights (2×16.00 g) of oxygen gas at 18° and 1 atm. and the product, 1 g.f.w. (34.0154 g) of H_2O_2, is dissolved in 200 g.f.w. of H_2O ($18.0154 \times 200 = 3603.08$ g), 188.2 kj of heat is given out." The resulting solution contains 1 g.f.w. of H_2O_2 in 200 g.f.w. of H_2O. The mole ratio of water in the solution is therefore 200, the mole ratio of H_2O_2 is 0.005. The mole fraction of H_2O_2 is $\frac{1}{200+1} = 0.004925$; of H_2O is $\frac{200}{200+1} = 0.995075$. The concentration in g.f.w. H_2O_2 per 1000 g water is $\frac{1000}{200 \times 18.0154} = 0.2775$. The solution contains $\frac{34.0154 \times 100}{(200 \times 18.0154) + 34.0154} = 0.935$ Wt. % of H_2O_2.

Explication

Arrangement.—Type, *voir* Vol. III, p. viii.

Colonne 1. *Formule.*—La formule présentée dans la colonne 1 identifie la substance dont la chaleur de formation par mol gr. (poids moléculaire en grammes) est indiqué dans la colonne 3. Les formes ou états polymorphiques nécessitant une description plus ample que celle donnée dans la colonne 2 sont indiqués par des signes arbitraires entre parenthèses, par exemple au moyen de lettres grecques, de chiffres romains ou de phrases descriptives. Les formes polymorphiques sont de plus identifiées dans la colonne 4 par la température de transition inscrites après l'abréviation Tr.

Colonne 2. *État physique.*—L'état physique auquel la chaleur de formation se rapporte est indiqué pour chaque substance dans la colonne 2. *Voir* la liste des abréviations ci-dessous. Tous les états sont considérés sous 1 atm. et à 18°C, à moins d'une annotation inscrite dans la colonne 3. Les chiffres et formules de la colonne 2 indiquent que la substance est en solution, une mol gr. étant dissoute dans X mol gr. du dissolvant. Dans le cas où le dissolvant n'est pas défini explicitement, il s'agit de l'eau. Lorsque le dissolvant est donné mais que la concentration n'est pas établie, la solution est "diluée." Ainsi 200 = "1 mol gr. de la substance (colonne 2) dissoute dans 200×18 g H_2O;" $200_{C_2H_5OH}$ = "1 mol gr. de la substance dissoute dans $200 \times 46{,}0$ g C_2H_5OH; CS_2 = "1 mol gr. de la substance dissoute dans une grande quantité de CS_2," etc.

Colonne 3. *Chaleur de formation.*—Les valeurs consignées dans la 3ème colonne sont le nombre de kilojoules, kj (absolu) de chaleur dégagée lorsqu'une mol gr. de la substance (indiquée dans la colonne 1) sous l'état donné dans la colonne 2 est produite à partir de ses éléments sous leur état type, à 18° et 1 atm. Conformément à la définition donnée ci-dessus, la chaleur de formation d'un élément se trouvant dans son état type est égale à zéro. L'état type de chaque élément peut être fixé par ce fait et par l'abréviation "Def." dans la colonne 3, en regard de la formule de l'élément. Les chaleurs de formation des ions sont basées sur la valeur arbitraire, 0, pour H^+ et sont pour les solutions diluées d'électrolytes complètement ionisés.

Précision.—Toutes les valeurs consignées dans ces tables ont été recalculées à partir des données expérimentales originales, en se servant de valeurs compatibles pour toutes les quantitées subsidiaires. Les chaleurs de réaction et de dilution peuvent donc être calculées par différence avec une précision aussi grande que possible. L'estimation de la précision est indiqué par un certain nombre de chiffres significatifs. Cette précision n'est pas la précision absolue, mais la précision de la réaction particulière utilisée pour calculer le chiffre donné (*voir* colonne 4). La précision absolue serait moindre que celle de la détermination la moins précise dans la série totale des réactions utilisées pour calculer la chaleur de formation à partir des éléments.

Colonne 4. *Méthode.*—Dans la colonne 4, on s'est efforcé d'indiquer d'une manière générale les réactions qui ont été employées pour le calcul des valeurs données. *Voir* la liste des abréviations ci-dessous. Dans cette colonne, les formules, par exemple MOH, indiquent que la chaleur de formation de M^+ dépend de la valeur dans les tables de la chaleur de formation de solutions diluées de MOH. Les chiffres se trouvant dans cette colonne, par ex. 3,65, non précédés de l'abréviation Tr., indiquent la chaleur de dissolution déterminée expérimentalement, sur laquelle est basée la valeur indiquée dans la colonne 4, par ex. 3,65 kj. Si les chiffres de cette colonne suivent le signe Tr., par ex. Tr. 0,8, cela indique que la chaleur de transition déterminée expérimentalement est par ex. 0,8 kj. Des annotations indiquent la température à laquelle la réaction a été mesurée.

Colonne 5. *Références bibliographiques.*—Les références se rapportent à la publication originale, excepté dans le cas de Thomsen où les valeurs sont ordinairement tirées de son livre. Dans le cas où la méthode employée par l'auteur n'est pas calorimétrique, par ex. coefficient de température de F.E.M., etc., la référence est munie d'un astérisque. Si la référence contient des valeurs déterminées à d'autres températures, elle est suivie du signe, °. Si elle contient des valeurs concernant la chaleur partielle de dissolution, ou autres quantités thermiques "partielles" la référence est suivie du signe, †. On entend par quantité thermique partielle le rapport $\frac{\partial \Delta Q}{\partial N_1}$ où N est la concentration de la substance, 1, en unités quelconques, ordinairement des fractions de molécules.

Calculs

Pour calculer la tonalité thermique d'un processus entrainant la disparition d'une ou de plusieurs substances sous les états donnés par les tables, et l'apparition d'autres ou des mêmes substances sous des états donnés dans les tables: additionner les chaleurs de formation des corps produits par le processus dans les états finaux, et soustraire de ce nombre la somme des chaleurs de formation des substances réagissantes prises dans leurs états initiaux. Ainsi:

Chaleur de réaction, ou tonalité thermique de la réaction.—CaO (crist.) + H_2O(liq.) = $Ca(OH)_2$(crist.), $\Delta Q = Q Ca(OH)_2 - [Q CaO + Q H_2O] = 988 - (634{,}9 + 286{,}2) = 66{,}9$ kj.

Chaleur de dissolution.—Si une détermination expérimentale directe est disponible, elle se trouvera dans la 3ème colonne sous la forme $8{,}66^{18}_{400}$ qui indique que la chaleur de dissolution d'une mol gr. de substance dans 400 mol gr. d'H_2O à 18° est de 8,66 kj. Si la température ou la dilution n'est pas indiquée, la valeur précise n'a pas été donnée dans l'original et la valeur est à considérer pour la "température ambiante" et pour une solution "diluée." Si la chaleur de dissolution n'est pas directement donnée dans la colonne 4, elle peut être trouvée en écrivant la réaction et en procédant au calcul comme avec les chaleurs de réaction ci-dessus. Par ex., pour trouver la chaleur de dissolution de $SrCl_2.2H_2O$ dans 400 mol d'eau, il faut écrire $SrCl_2.2H_2O = SrCl_{2(400)} + 2H_2O$; $\Delta Q = 874{,}7 + 2 \times 286{,}2 - 1438{,}4 = 8{,}7$ kj.

Chaleur de dilution.—La chaleur moléculaire intégrale de dilution c.à.d. la chaleur obtenue en diluant avec y mol d'H_2O, une solution d'une mol gr. de la substance dans x mol d'H_2O, est l'excès de la chaleur de formation d'une mol gr. de la substance dans la solution finale sur sa chaleur de formation dans la solution initiale. Ainsi: la chaleur de dilution d'une mol d'H_2SO_4 dans 99 mol d'eau, portée à une mol d'H_2SO_4 dans 799 mol d'eau est égale à $871{,}6 - 867{,}8 = 3{,}8$ kj.

Chaleur de transition.—Si les deux formes de la substance peuvent être obtenues à 18° et sous une atmosphère, il faut

soustraire la chaleur de formation de la forme finale de celle de la forme initiale. Dans le cas de transitions qui ne peuvent être réalisées sous une atmosphère qu'à des températures différentes de 18°, la chaleur de transition se trouvera dans la colonne 3 après l'abréviation Tr. Par ex. la chaleur de transition de Mn_α à Mn_β est donnée sous la forme Mn_α . . . Tr.; $5{,}5\overset{1100}{\beta}$, qui signifie que 5,5 kj de chaleur sont dégagés lorsqu'un atome gramme de α-manganèse se transforme en β-manganèse à 1100°.

Chaleurs d'ionisation.—La chaleur de formation d'une solution complètement ionisée d'une substance donnée peut être considérée comme la somme des chaleurs de formation de ses ions. C'est pourquoi, si l'on connait la chaleur de formation d'une solution complètement ionisée et celles de tous ses ions sauf un, la chaleur de formation de ce dernier ion peut être calculée. Cette méthode a été utilisée pour calculer les chaleurs de formation des ions données dans la table, la chaleur de formation de H^+ étant arbitrairement prise comme zéro. Inversement, connaissant les chaleurs de formation des ions, on peut trouver la chaleur de formation d'une solution diluée d'un electrolyte fort, par addition des chaleurs de formation de ses ions; par ex., la chaleur de formation de $(NH_4)_2SeO_4(aq.) = 2Q\overset{+}{NH_4} + Q\overset{--}{SeO_4} = 2 \times 132{,}7 + 613 = 878{,}4$ kj. D'une façon analogue, la chaleur d'ionisation d'un electrolyte faible peut être calculée en totalisant les chaleurs de formation de ses ions et en soustrayant du résultat sa chaleur de formation; par ex., $H_2O = \overset{-}{OH} + \overset{+}{H}$; $\Delta Q = Q\overset{-}{OH} + Q\overset{+}{H} - QH_2O = 228{,}2 + 0 - 286{,}2 = -58{,}0$ kj.

ABRÉVIATIONS, SIGNES, FORMES

Abréviations

amorp.	Amorphe, état cryptocristallin, ou état solide mal défini.
aq.	Solution aqueuse diluée.
c	Macrocristallin.
coll.	Gel ou sol colloïdal.
Def.	État type.
dil.	Dépend d'une chaleur de dilution.
dissoc.	Dépend d'une chaleur de dissociation.
extrap.	Extrapolé.
gls.	Un verre ou un solide provenant d'un liquide surfondu.
(ideal)	Dans la condition indiquée par la formule, par ex., pour N_2O_4 le mot "(ideal)" dans la colonne 2 indique que la chaleur de formation est celle pour un gaz composé seulement de molécules de N_2O_4.
liq.	Liquide.
mix.	Chaleur de mélange.
N	De la chaleur de neutralisation.
ppt.	Précipité ou de la chaleur de précipitation.
sat.	En solution saturée dans l'H_2O.

Signes dans la table

*	Par méthodes indirectes non calorimétriques.
&	Par plusieurs méthodes différentes.
∞	Dans une quantité infinie d'H_2O à moins d'une autre indication.

Signes dans la colonne des Ref. bibl.

*	Par méthodes indirectes non calorimétriques.
†	Comprend la détermination ou la compilation de quantités "partielles."
°	Comprend des déterminations à des températures différentes de 18°.

Formes

$+X_2$	Déduit de la chaleur de réaction avec X_2.
Tr.; $0{,}92^{427}_{(i)}$	La chaleur de transition dans la forme cristalline I est 0,92 kj à 427°.

Exposants ainsi

2600^{35}	Un exposant indique la température.

Indices

365_{100}	La dilution de la solution finale est de 100 mol H_2O par mol gr. de substance.
365_{KOH}	Dans une solution diluée de KOH.
$365_{KOH(100)}$	Le solvant est constitué par une mol KOH dans 100 mol H_2O.
$365_{24\ KCN}$	Le solvant est constitué par une solution contenant 24 mol de KCN par mol de corps dissout.

Exemples Explicatifs

H_2O.—L'information donnée dans les colonnes 2 et 3 est équivalente à ce qui suit: "Lorsque 2 atomes gr. (2,0154 g) du gaz hydrogène (H_2) à 18° et sous 1 atm. réagissent avec un atome gr. (16,00 g) d'oxygène à 18° et sous 1 atm. pour produire une mol gr. (18,0154 g) d'H_2O liquide à 18° et une atm., il y a dégagement de 286,2 kj de chaleur." Ceci est équivalent (*voir* les facteurs de conversion donnés ci-dessous) à $0{,}23895 \times 286{,}2 = 68{,}39$ kg-cal_{15}, etc.

Cl^-.—L'information donnée dans les colonnes 2, 3 et 4 est équivalente à ce qui suit: "La chaleur de formation d'une solution complètement ionisée contenant une mol gr. (35,458 g) de Cl^- et la quantité équivalente d'un ion positif (par ex. une solution de $Cl^- + H^+ = HCl_\infty$) est égale à la somme de la chaleur de formation de Cl^-, $Q = 165{,}55$ et de H^+, $Q = 0$, qui est $Q = 165{,}55$ kj."

$H_2O_{2(200)}$.—L'information donnée dans les colonnes 2 et 3 est équivalente à ce qui suit: "Lorsque 2 atomes grammes ($2 \times 1{,}0077$ g) du gaz hydrogène à 18° et sous 1 atm. réagissent avec 2 atomes gr. ($2 \times 16{,}00$ g) du gaz oxygène à 18° et sous 1 atm. et que le produit 1 mol gr. (34,0154 g) d'H_2O_2, est dissout dans 200 mol gr. d'H_2O ($18{,}0154 \times 200 = 3603{,}08$ g), il y a dégagement de 188,2 kj de chaleur." La solution résultante contient une mol gr. H_2O_2 dans 200 mol gr. d'H_2O. Le rapport moléculaire de l'eau dans la solution est ainsi de 200, le rapport moléculaire de H_2O_2 est 0,005. La fraction moléculaire de H_2O_2 est $\frac{1}{200+1} = 0{,}004925$; celle de H_2O est $\frac{200}{200+1} = 0{,}995075$. La concentration en mol gr. H_2O_2 par 1000 g d'eau est de $\frac{1000}{200 \times 18{,}0154} = 0{,}2775$. La solution contient $\frac{34{,}0154 \times 100}{(200 \times 18{,}0154) + 34{,}0154} = 0{,}935$ pour-cent poids de H_2O_2.

ERKLÄRUNG

Anordnung.—Standard, *siehe* Bd. III, S. viii.

Reihe 1. *Formel.*—Die Formel, welche in der ersten Reihe erscheint, bezeichnet den Stoff dessen Bildungswärme per 1 G.F.G. (Gramm-Formel-Gewicht) in der Reihe 3 erscheint. Polymorphe Formen, oder Zustände, die eine besondere Beschreibung erfordern, als die, welche in der Reihe 2 angegeben ist, sind durch willkürlich gewählte Zeichen in Klammern angeführt, z.B. durch griechische Buchstaben, römische Zahlen, oder Bemerkungen. Die polymorphen Formen sind weiter durch die Umwandlungstemperatur gekennzeichnet, welche in der Reihe 4 als hinaufgesetzter Index zu Tr. angegeben ist.

Reihe 2. *Physikalischer Zustand.*—Für jeden Stoff ist der physikalische Zustand, auf den sich die Bildungswärme bezieht, in der Reihe 2 angegeben. Abkürzungen *siehe* unten. Alle Zustände gelten für 1 Atmosphäre und 18°C, wenn nicht durch hinaufgesetzte Zeichen in der Reihe 3 etwas anderes angegeben ist. Zahlen oder Formeln in der Reihe 2 bedeuten, dass der Stoff in Lösung sich befindet: es ist 1 G.F.G. gelöst in *X* G.F.G. des Lösungsmittels. Wasser ist das Lösungsmittel dorten, wo nichts besonderes bezeichnet ist. Ist das Lösungsmittel gegeben, aber

die Konzentration nicht festgestellt, so ist die Lösung "verdünnt." Z.B. 200 = "1 G.F.G. von dem Stoffe (Reihe 2) ist gelöst in 200×18 g H_2O;" $200_{C_2H_5OH}$ = "1 G.F.G. des Stoffes gelöst in 200×46 g C_2H_5OH;" CS_2 = "1 G.F.G. des Stoffes gelöst in einer grossen Menge CS_2;" u.s.w.

Reihe 3. *Bildungswärme.*—Die Zahlen in der Reihe 3 bedeuten Kilojoule, kj (absolut), als diejenige Wärmemenge, welche *entwickelt* wird, wenn 1 G.F.G. des Stoffes (in der Reihe 1 angegeben) in dem in der Reihe 2 angegebenen physikalischen Zustand, aus dem im Normalzustand befindlichen Elementen bei 18°C und bei 1 Atmosphäre, entsteht. Entsprechend des gegebenen Definition, ist die Bildungswärme eines Elementes im Normalzustande Null. Der Normalzustand irgend eines Elementes kann so gefunden werden und auch durch die Abkürzung "Def." in der Reihe 3, gegenüber dem Zeichen des Elementes. Die Bildungswärmen von Ionen gründen sich auf der Basis, dass für H^+, willkürlich Null gesetzt wird, sie gelten für verdünnte Lösungen vollständig ionisierter Elektrolyte.

Genauigkeit.—Alle in dieser Tabelle angegebenen Werte, wurden nach dem im Original befindlichen experimentellen Daten neu gerechnet, indem festgelegte Werte für alle Hilfsgrössen benützt wurden. Die Reaktions- und Verdünnungs-Wärmen können also durch Differenzen berechnet werden, deren Genauigkeit so weit als bekannt geht. Die geschätzte Genauigkeit ist durch die Anzahl der gross geschriebenen Zahlen ausgedrückt. Diese Genauigkeit ist nicht die absolute Genauigkeit, aber die Genauigkeit der Teilreaktion die verwendet worden ist, um die der angegebenen Zahl zu berechnen (*siehe* Reihe 4). Die absolute Genauigkeit wird kleiner sein, als die wenigst genaue Bestimmung in der gesamten Kette der Reaktionen, die gebraucht worden sind, um die Bildungswärmen aus den Elementen zu berechnen.

Reihe 4. *Methode.*—In dieser Reihe ist ein Versuch gemacht worden, in einer allgemeinen Weise die Reaktionen zu verzeichnen, die bei der Berechnung der angegebenen Werte verwendet worden sind. Abkürzungen *siehe* unten. Formeln in dieser Reihe, z.B. MOH, zeigen an, dass die Bildungswärme von M^+ von den in der Tafel Angaben der Bildungswärme der verdünnten Lösung von MOH abhängt. Zahlen, z.B. 3,65, in dieser Reihe, welchen nicht ein Tr. vorausgeht, geben die experimentell bestimmte Lösungswärme an, auf Grund derer die Zahl in der Reihe 3 ruht. In diesem Zusammenhang bedeutet die Zahl 3,65, dass die experimentell bestimmte Lösungswärme 3,65 kj beträgt. Zahlen in dieser Reihe, welche Tr. folgen, z.B. Tr. 0,8, bedeuten die experimentell bestimmte Umwandlungswärme in kj, (0,8 kj). Hinaufgesetzte Indizes bedeuten die Temperatur bei welcher die Reaktion gemessen worden ist.

Reihe 5. *Literatur-Verzeichnis.*—Die Hinweise beziehen sich immer auf die Originalarbeit, ausser im Falle von Thomsen, wo gewöhnlich die Werte aus seinem Buche genannt werden. Sind vom Author nicht-calorimetrische Methoden angewendet worden z.B. Temperaturkoeffizient der elektromotorischen Kraft, u.s.w., so ist die Literaturangabe mit einem Stern versehen; enthält sie Werte die bei einer anderen Temperatur bestimmt worden sind, so erhält sie das Zeichen, °, oder enthält sie partielle Lösungswärmen oder andere "partielle" Werte einer thermischen Grösse, wird sie mit dem Zeichen, †, versehen. Unter partielle thermische Grössen versteht man den Ausdruck $\frac{\partial \Delta Q}{\partial N_1}$ in welchem N_1 die Konzentration des Stoffes 1 in irgend einer Einheit, gewöhnlich in Molbrüchen, bedeutet.

Berechnungen

Die Wärmetönung irgend eines Prozesses, der das Verschwinden eines Stoffes oder mehrerer, von einem in der Tabelle angegebenen Zustand und das Auftreten anderen Stoffen, oder derselben Stoffe, in einem Zustande der in der Tabelle angegeben, zur Folge hat, bestimmt man, wie folgt: Man addiere die Bildungswärmen der Reaktionsprodukte des Prozesses in dem Endzustand zusammen und subtrahiert davon die Summe der Bildungswärmen der Ausgangsprodukte in ihren Ausgangszuständen, z.B.

Reaktionswärme.—CaO (krist.) + H_2O (flüss.) = $Ca(OH)_2$ (krist.), $\Delta Q = Q Ca(OH)_2 - [Q CaO + Q H_2O] = 988 - [634{,}9 + 286{,}2] = 66{,}9$ kj.

Lösungswärme.—Ist eine direkte experimentelle Bestimmung vorhanden, findet man in der Reihe 3 die Form $8{,}66^{18}_{400}$, das bedeutet, die Lösungswärme für 1 G.F.G. des Stoffes in 400 Molen Wasser bei 18°C ist 8,66 kj. Ist die Temperatur oder die Verdünnung nicht angegeben, so ist der genaue Wert nicht im Original zu finden, der Wert gilt dann für "Zimmertemperatur" und eine "verdünnte" Lösung. Ist die Lösungswärme nicht direkt in der Reihe 4 angegeben, so kann man sie finden, wenn man die Reaktion niederschreibt und dann so vorgeht, wie oben, bei der Bestimmung der Reaktionswärmen. Um z.B. die Lösungswärme von $SrCl_2.2H_2O$ in 400 Molen Wasser zu finden, schreibe man, $SrCl_2.2H_2O = SrCl_{2(400)} + 2H_2O$; $\Delta Q = 874{,}7 + 2 \times 286{,}2 - 1438{,}4 = 8{,}7$ kj.

Verdünnungswärme.—Die molare integrale Verdünnungswärme ist die Wärme, welche bei der Verdünnung mit y Molen Wasser, einer Lösung von 1 G.F.G. des Stoffes in x Molen Wasser, entsteht. Sie ist der Überschuss der Bildungswärme die entsteht, wenn 1 G.F.G. des Stoffes zur Endkonzentration gelöst wird, gegen die Bildungswärme bei der Herstellung der Anfangskonzentration. Z.B. die Verdünnungswärme eines Moles H_2SO_4 in 99 Molen Wasser zu 1 Mol H_2SO_4 in 799 Molen Wasser ist 871,6 − 867,8 = 3,8 kj.

Umwandlungswärme.—Können beide Formen des Stoffes bei 18°C und 1 Atmosphäre erhalten werden, subtrahiere man die Bildungswärme der Endform von der der Anfangsform. Für Umwandlungen, die bei 1 Atmosphäre nur bei einer von 18°C verschiedener Temperatur beobachtet werden können, kann man die Umwandlungswärme in der Reihe 3 nach der Abkürzung Tr. finden. Z.B. ist die Umwandlungswärme von Mn_α, zu Mn_β durch die Form M_α . . . Tr.; $5{,}5^{1100}_{\beta}$ gegeben, das bedeutet, bei 1100°C, wenn die Umwandlung von 1 Grammatom α-Mangan in β-Mangan vor sich geht, werden 5,5 kj entwickelt.

Ionisationswärmen.—Die Bildungswärme einer vollständig ionisierten Lösung eines Stoffes kann betrachtet werden, als die Summe der Bildungswärmen seiner Ionen. Deshalb, kennt man die Bildungswärme einer vollständig ionisierten Lösung und ist die Bildungswärme aller Ionen bis auf eines bekannt, so kann die Bildungswärme des anderen Ions berechnet werden. Diese Methode ist verwendet worden um die, in der Tabelle angegebenen, Bildungswärmen für die Ionen zu berechnen. Die Bildungswärme für das Wasserstoff-Ion H^+ wurde willkürlich Null gesetzt. Umgekehrt, kennt man die Bildungswärmen der Ionen, kann man die Bildungswärmen der verdünnten Lösung eines starken Elektrolyten durch Addition der Bildungswärmen seiner Ionen finden. Es ist z.B. die Bildungswärme von $(NH_4)_2SeO_4(aq.) = 2Q NH_4^+ + Q SeO_4^= = 2 \times 132{,}7 + 613 = 878{,}4$ kj. Ähnlich, kann man die Ionisationswärme eines schwachen Elektrolyten berechnen, indem man von der Summe der Ionisationswärmen seiner Ionen, die Bildungswärmen desselben subtrahiert. Z.B. $H_2O = OH^- + H^+$; $\Delta Q = Q OH^- + Q H^+ - Q H_2O = 228{,}2 + 0 - 286{,}2 = -58{,}0$ kj.

ABKÜRZUNGEN, ZEICHEN UND FORMEN

Abkürzungen

amorp.	Amorph, kryptokristallinisch, oder schlecht definierter Zustand.
aq.	Verdünnte wässrige Lösung.
c	Makrokristallin.
coll.	Kolloidales Gel oder Sol.
Def.	Normalzustand.

dil.	Hängt von einer Verdünnungswärme ab.
dissoc.	Hängt von einer Dissoziationswärme ab.
extrap.	Extrapoliert.
gls.	Ein Glas oder eine feste unterkühlte Flüssigkeit.
(ideal)	Betrifft die Bedingungen, welche die Formel ausdrückt, z.B. für N_2O_4 bedeutet das Wort "(ideal)" in der Reihe 2, dass die Bildungswärme für ein Gas gilt, welches nur aus N_2O_4 Molekeln besteht.
liq.	Flüssig.
mix.	Mischungswärme.
N	Von der Neutralisationswärme.
ppt.	Niedergeschlagen, oder von der Niederschlagswärme.
sat.	In wässriger gesättigter Lösung.

Zeichen

In der Tafel

*	Durch eine indirekte nicht kalorimetrische Methode.
&	Durch mehrere verschiedene Methoden.
∞	In einer unendlich grossen Menge Wasser, wenn nichts anderes angegeben.

In der Reihe der Literaturangabe

*	Durch eine indirekte nicht kalorimetrische Methode.
†	Enthält Messungen oder Sammlungen von "partielle" Grössen.
°	Enthält Messungen bei einer von 18°C verschiedenen Temperatur.

Formen

$+X_2$	Abgeleitet von Reaktionswärme mit X_2.
Tr.; $0{,}92^{427}_{(1)}$	Die Umwandlungswärme zur Kristallform, I, ist 0,92 kj bei 427°C.

Hinaufgesetzter Index

2600^{25}	Der Index bedeutet die Temperatur.

Hinuntergesetzter Index

365_{100}	Der Index bedeutet, dass die Verdünnung der Endlösung ist 100 Mole Wasser auf 1 G.F.G. des Stoffes.
365_{KOH}	In einer verdünnten KOH-Lösung.
$365_{KOH(100)}$	Das Lösungsmittel ist 1 Mol KOH auf 100 Mole Wasser.
$365_{24\ KCN}$	Das Lösungsmittel ist eine Lösung, welche 24 Mole von KCN pro 1 Mol des gelösten Stoffes enthält.

Beispiele

H_2O.—Die in der Reihe 2 und 3 gegebenen Daten entsprechen dem folgendem: "Wenn 2 Grammatome, (2,0154 g) Wasserstoffgas (H_2), bei 18°C und 1 Atmosphäre mit 1 Grammatom (16 g) Sauerstoff (O), bei 18°C und 1 Atmosphäre, miteinander reagieren und dabei 1 G.F.G. flüssiges Wasser (18,0154 g) bei 18°C und 1 Atmosphäre geben, so werden 286,2 kj Wärme entwickelt." Das ist äquivalent (*siehe* die unten angegebenen Umrechnungsfaktoren) $0{,}23895 \times 286{,}2 = 68{,}39$ kg-cal_{15}, u.s.w.

Cl^-.—Die Daten, welche in der Reihe 2 und 3 gegeben sind, entsprechen dem folgendem: "Die Bildungswärme einer vollständig ionisierten Lösung, die 1 G.F.G. von Cl^- enthält (35,458 g) und die gleiche Menge eines positiven Ions (z.B. eine Lösung von $Cl^- + H^+ = HCl_\infty$), ist die Summe der Bildungswärmen von Cl^-, $Q = 165{,}55$, und von H^+, $Q = 0$, zusammen also 165,55 kj."

$H_2O_{2(200)}$.—Die Daten, welche in der Reihe 2 und 3 gegeben sind, entsprechen dem folgendem: "Wenn 2 Grammatome ($2 \times 1{,}0077$ g) Wasserstoffgas bei 18°C und 1 Atmosphäre mit 2 Grammatomen (2×16 g) Sauerstoffgas von 18°C und 1 Atmosphäre, reagieren und das Reaktionsprodukt 1 G.F.G. (34,0154 g) H_2O_2 gelöst in 200 G.F.G. von H_2O ($18{,}0154 \times 200 = 3603{,}08$ g) ist, so werden 188,2 kj als Reaktionswärme frei." Die sich ergebende Lösung enthält 1 G.F.G. von H_2O_2 in 200 G.F.G. Wasser. Das Molenverhältnis des Wassers ist also in der Lösung 200, das Molenverhältnis des H_2O_2 ist 0,005. Der Molenbruch für H_2O_2 ist $\frac{1}{200+1} = 0{,}004925$; für H_2O $\frac{200}{200+1} = 0{,}995075$. Die Konzentration in G.F.G. H_2O_2 pro 1000 g Wasser ist

$$\frac{1000}{200 \times 18{,}0154} = 0{,}2775.$$

Die Lösung enthält $\frac{34{,}0154 \times 100}{(200 \times 18{,}0154) + 34{,}0154} = 0{,}935$ Gewichtsprozent auf H_2O_2.

SPIEGAZIONE

Disposizione.—Standard, *vedi* Vol. III, p. viii.

Colonna 1. *Formula.*—Le formule contenute nella colonna 1 indicano le sostanze di cui nella colonna 3 sono riportati i calori di formazione per p.f.g. (peso in grammi corrispondente alla formula). Le forme polimorfiche o gli stati i quali richiedono per essere definiti indicazioni più ampie di quelle riportate nella colonna 2 sono indicati con segni arbitrari tra parentesi, *p.e.* con lettere greche, numeri romani, o altri qualificativi. Le forme polimorfiche sono inoltre indicate con la temperatura di trasformazione che è riportata nella colonna 4 dopo l'abbreviazione Tr.

Colonna 2. *Stato fisico.*—Per ogni sostanza, lo stato fisico al quale si riferisce il calore di formazione è indicato nella colonna 2. *Vedi* più oltre la lista delle abbreviazioni. Tutti gli stati, quando non è diversamente indicato nella colonna 3, sono considerati alla pressione di 1 atmosfera e alla temperatura di 18°C. Le formule nella colonna 2 indicano che la sostanza è in soluzione e che un p.f.g. è disciolto in *X* p.f.g. di solvente. Dove il solvente non è indicato, si intende che si tratta dell'acqua. Dove è indicato il solvente, ma non la concentrazione, s'intende che si tratta di soluzione diluita. Così 200 = "1 p.f.g. della sostanza (della col. 1) disciolta in 200×18 g di H_2O;" $200_{C_2H_5OH}$ = "1 p.f.g. della sostanza disciolta in $200 \times 46{,}0$ g di C_2H_5OH;" CS_2 = "1 p.f.g. della sostanza disciolta in una grande quantità di CS_2," etc.

Colonna 3. *Calore di formazione.*—I valori della colonna 3 sono in numero di kilojoules, kj (assoluti) di calore *svolti* quando un p.f.g. della sostanza (che figura nella colonna 1 e nello stato indicati nella colonna 2) si forma dagli elementi considerati nelle condizioni normali alla temperatura di 18° e alla pressione di 1 atm. Secondo la definizione data sopra il calore di formazione di un elemento nel suo stato normale è 0. Lo stato normale di un elemento qualsiasi può essere riconosciuto da questo fatto e dall' abbreviazione "Def." nella colonna 3 in corrispondenza del simbolo dell'elemento. I calori di formazione degli joni sono riferiti al valore arbitrario 0 per H^+ e si riferiscono a soluzioni diluite di elettroliti completamente jonizzati.

Precisione.—Tutti i valori riportati in questa tabella sono stati ricalcolati dai dati originali sperimentali usando valori ben vagliati per tutte le quantità sussidiarie. I calori di reazione e di diluizione possono quindi essere calcolati per differenza con l'accuratezza maggiore che è possibile. La precisione che si può raggiungere è indicata dal numero delle cifre significative. Questa precisione non è quella assoluta; ma la precisione della particolare reazione usata per calcolare il valore adottato (*v.* colonna 4). La precisione assoluta è inferiore a quella della determinazione meno accurata nella serie di reazioni utilizzata per il calcolo del calore di formazione a partire dagli elementi.

Colonna 4. *Metodo.*—Nella colonna 4 si è fatto il tentativo di indicare in una maniera generale le reazioni utilizzate per il calcolo dei valori riportati. *Vedi* la lista delle abbreviazioni più oltre. Le formule di questa colonna per es. MOH, indicano che il calore di formazione di M^+ dipende dal valore che nella tabella è riportato per il calore di formazione della soluzione diluita di MOH. Le cifre di questa colonna, *p. e.* 3,65; quando non sono precedute dall'abbreviazione Tr., indicano il valore sperimentale del calore di soluzione sul quale è basato il valore della colonna 4, *p.e.* 3,65 kj. I numeri di questa colonna preceduti da Tr., per es. Tr. 0,8; indicano il calore di trasformazione determinato speri-

mentalmente, per es. 0,8 kj. I numeri scritti sopra indicano le temperature alle quali le reazioni sono state misurate.

Colonna 5. Letteratura.—La citazione si riferisce alla pubblicazione originale; solo i valori del Thomsen sono generalmente presi dal suo libro. Quando il metodo usato dall'autore non è quello calorimetrico (come per es. quando il valore è dedotto dal coefficiente di temperatura della F.E.M., etc.) la citazione è munita di asterisco. Se la citazione contiene valori determinati ad altre temperature, è seguita dal simbolo, °, e se contiene valori per il calore parziale di soluzione o altre quantità termiche "parziali," la citazione è seguita dal simbolo, †. Per quantità termiche parziali si intendono i valori $\frac{\partial \Delta Q}{\partial N_1}$ dove N_1 è la concentrazione della sostanza, 1, in qualsiasi unità, generalmente frazioni di grammimolecole.

Calcolo

Per calcolare il calore di qualsiasi processo che implica la scomparsa di una o più sostanze negli stati indicati nella tabella, e la comparsa di altre o delle stesse sostanze negli stati indicati nella tabella, si sommano i calori di formazione dei prodotti finali e dalla somma si sottraggono i calori di formazione delle sostanze reagenti nei loro stati iniziali. Per esempio:

Calore di reazione.—CaO (crist.) $+ H_2O$ (liq.) $= Ca(OH)_2$ (crist.), $\Delta Q = Q Ca(OH)_2 - [Q CaO + Q H_2O] = 988 - [634,9 + 286,2] = 66,9$ kj.

Calore di soluzione.—Se esiste un valore sperimentale, lo si trova nella colonna 3 sotto la forma $8,66^{18}_{400}$ la quale indica che il calore di soluzione di un p.f.g. della sostanza in 400 moli di H_2O a 18° è 8,66 kj. Se la temperatura o la diluizione non sono indicate, vuol dire che non lo sono nel lavoro originale, ed i valori si riferiscono alla temperatura ambiente e a soluzioni diluite. Se il calore di soluzione non è direttamente indicato nella colonna 4, lo si può stabilire scrivendo la reazione e procedendo nel calcolo come è indicato sopra per i calori di reazione. Per es., si supponga di voler calcolare il valore di soluzione di $SrCl_2.2H_2O$ in 400 moli di acqua; allora si ha: $SrCl_2.2H_2O = SrCl_{2(400)} + 2H_2O$; $\Delta Q = 874,7 + 2 \times 286,2 - 1438,4 = 8,7$ kj.

Calore di diluizione.—Il calore molecolare integrale di diluizione (e cioè il calore che si ha nel diluire con y moli di H_2O una soluzione di un p.f.g. della sostanza in x moli di H_2O), è la differenza tra il calore di formazione di un p.f.g. della sostanza nella soluzione finale e quello nella soluzione iniziale. Per es. il calore che si ha diluendo una soluzione di una mole di H_2SO_4 in 99 moli di acqua fino a raggiungere la concentrazione di una mole di H_2SO_4 in 799 moli di acqua è 871,6 − 867,8 = 3,8 kj.

Calore di trasformazione.—Se tutte le due forme della sostanza possono ottenersi a 18° e alla pressione di 1 atmosfera, si sottrae il calore di formazione della forma finale da quello della forma iniziale. Per le trasformazioni che possono effettuarsi al di sotto di 1 atm. soltanto a temperature diverse da 18°, il calore di trasformazione si trova nella colonna 3 dopo l'abbreviazione Tr. Per es., il calore di trasformazione da Mn_α a Mn_β è indicato così: Mn_α . . . Tr.; $5,5^{1100}_{\beta}$, il che significa che quando un grammo atomo di α-manganese si trasforma in β-manganese a 1100° si svolgono 5,5 kj.

Calore di jonizzazione.—Il calore di formazione di una soluzione completamente jonizzata di una sostanza può considerarsi come la somma dei calori di formazione dei suoi joni. Quindi se si conosce il calore di formazione di una soluzione completamente jonizzata, e si conosce o ammette quello di tutti i suoi joni meno uno, si può calcolare il calore di formazione di quest'ultimo. Questo metodo è stato usato per calcolare il calore di formazione degli joni dati nella tabella, assumendo arbitrariamente eguale a 0 il calore di formazione di H^+. Inversamente conoscendo i calori di formazione degli joni si può stabilire il calore di formazione di una soluzione diluita di un elettrolita forte addizionando i calori di formazione dei suoi joni: per es., il calore di formazione di $(NH_4)_2SeO_4$ (aq.) $= 2 Q NH_4^+ + Q SeO_4^= = 2 \times 132,7 + 613 = 878,4$ kj. Similmente il calore di jonizzazione di un elettrolita debole si può calcolare sommando i calori di formazione dei suoi joni e sottraendo poi il suo calore di formazione: per es., $H_2O = OH^- + H^+$, $\Delta Q = Q OH^- + Q H^+ - Q H_2O = 228,2 + 0 - 286,2 = -58,0$ kj.

ABBREVIAZIONI, SEGNI E FORMULE

Abbreviazioni

amorp.	Amorfo, criptocristallino o stato solido mal definito.
aq.	Soluzione acquosa diluita.
c	Macrocristallino.
coll.	Gelo o solo colloidale.
Def.	Condizioni normali.
dil.	Dedotto da un calore di diluizione.
dissoc.	Dedotto da un calore di dissociazione.
extrap.	Estrapolato.
gls.	Un vetro o un liquido sopraraffreddato.
(ideal)	Nelle condizioni indicate dalla formula," p. es. per N_2O_4 la parola "(ideal)" nella colonna 2 indica che il calore di formazione si riferisce ad un gas formato soltanto di molecole N_2O_4.
liq.	Liquido.
mix.	Calore di mescolamento.
N	Dal calore di neutralizzazione.
ppt.	Precipitato o dal calore di precipitazione.
sat.	In soluzione satura in H_2O.

Segni

Nella Tabella

*	Con metodo indiretto non calorimetrico.
&	Con parecchi metodi differenti.
∞	In una quantità infinita di H_2O se non è altrimenti indicato.

Nella Colonna Delle Citazioni

*	Con metodi indiretti non calorimetrici.
†	Include la determinazione o la compilazione di quantità "parziali."
°	Include determinazioni a temperature diverse da 18°.

Forme

$+X_2$	Dedotto da calore di reazione con X_2.
Tr.; $0,92^{427}_{(I)}$	Il calore di trasformazione nella forma cristallina "I" è 0,92 kj a 427°.

Numeri Soprascritti

2600^{35}	Un numero soprascritto indica la temperatura.

Numeri Sottoscritti

365_{100}	La diluizione della soluzione finale è 100 moli di H_2O per p.f.g. di sostanza.
365_{KOH}	In una soluzione diluita di KOH.
$365_{KOH(100)}$	Il solvente è una mole di KOH in 100 moli di H_2O.
$365_{24\ KCN}$	Il solvente è una soluzione contenente 24 moli di KCN per mole di sostanza disciolta.

Esempi Illustrativi

H_2O.—Le notizie riportate nelle colonne 2 e 3 significano quanto segue: "Quando due grammi atomi (g 2,0154) di idrogeno gassoso (H_2) a 18° e una atm. reagiscono con un grammo atomo (g 16,00) di ossigeno gas a 18° e una atm., per produrre un p.f.g. (g 18,0154) di H_2O liquida a 18° e a una atm., si sviluppano 286,2 kj." Questi equivalgono (*vedi* i fattori di conversione dati più sotto) a $0,23895 \times 286,2 = 68,39$ kg-cal_{15}.

Cl^-.—Le notizie date nelle colonne 2, 3 e 4 significano quanto segue. "Il calore di formazione di una soluzione completamente jonizzata contenente un p.f.g. (g 35,458) di Cl^- e la quantità equivalente di un jone positivo qualsiasi (per es. una soluzione di

$Cl^- + H^+ = HCl_\infty$) è la somma del calore di formazione di Cl^-, $Q = 165{,}55$, e di H^+, $Q = 0$, e cioè $Q = 165{,}55$ kj."

$H_2O_{2(200)}$.—I numeri riportati nelle colonne 2 e 3 significano quanto segue. "Quando due gr. atomi (g $2 \times 1{,}0077$) di idrogeno gassoso a 18° e a una atm. reagiscono con 2 grammi atomi (g $2 \times 16{,}00$) di ossigeno gassoso a 18° e a una atm., e il prodotto, 1 p.f.g. (g 34,0154) di H_2O_2 si scioglie in 200 p.f.g. di H_2O ($18{,}0154 \times 200 = 3603{,}08$ g) si sviluppano 188,2 kj." La soluzione risultante contiene un p.f.g. di H_2O_2 in 200 p.f.g. di H_2O. Il rapporto fra il numero di molecole di acqua e di acqua ossigenata è perciò 200, e quello tra le molecole di H_2O_2 e di H_2O è di 0,005. La frazione di mole di H_2O_2 è $\frac{1}{200+1} = 0{,}004925$; e di H_2O è $\frac{200}{200+1} = 0{,}995075$. La concentrazione in p.f.g. di H_2O_2 per 1000 g acqua è

$$\frac{1000}{200 \times 18{,}0154} = 0{,}2775.$$

La soluzione contiene: $\frac{34{,}0154 \times 100}{(200 \times 18{,}0154) + 34{,}0154} = 0{,}935$ per cento in peso di H_2O_2.

Conversion factors

To convert kj to: / Pour convertir kj en: / Um kj zu verwandeln in: / Per convertire i kj in:	Multiply by / Multiplier par / ist zu multiplizieren mit / Moltiplicare per	Log_{10} =
kg cal_{15}	0.23895	$\bar{1}.378304$
BTU_{60}	0.94823	$\bar{1}.976912$
CTU_{15}	0.52679	$\bar{1}.721639$
l-atm	9.8690	0.994272
kg m	101.972	2.008479
ft. lb	737.56	2.867798
h.p. hr (elec.)	0.00037236	$\bar{4}.570959$
cheval vap. hr	0.00037767	$\bar{4}.577116$
kw hr (abs.)	0.00027778	$\bar{4}.443698$
volt Faraday (abs.)	0.010363	$\bar{2}.015473$
volt amp. sec^{-1}	1000.	3.000000
quanta sec^{-1}	1.5258×10^{36}	36.183494

Å-Ɐ Table

Formula	State	Q, kj	Method	Lit.
Oxygen				
O_2	gas	0	Def.	
$O_{2(II)}$	c		Tr.; $0.701^{-221}_{(I)}$	(346)
$O_{2(III)}$	c		Tr.; $0.073^{-250}_{(II)}$	(346)
O_2	aq.	13.8	13.8*	(426, 1047,* 1050)
	Pt	736	$+Pt^{60}$	(727)
O	gas	− 341	dissoc.*	(197.5, 347)
O_3	gas	− 144	dissoc.; &	(76, 547, 575, 739, 790*)
	aq.	− 136	8*	(368,* 888*)
O_4	gas	+ 0.5	dissoc.*	(636*)
Hydrogen				
H_2	gas	0	Def.	
	sat.	5.94	5.94	(880,* 1047†)
	in Pt	57.8	+ Pt	(357, 727)
	as Pd_2H	74.2	+Pd	(357, 445,* 726)
H	gas	− 211	dissoc.*	(299.5, 312.5, 605, 606, 607,* 641.1,* 915.5, 1063*)
H^+	∞	0	Def.	
OH (*cf.* p. 212)	C_2H_5OH	− 29.0	$HCl_{C_2H_5OH}$	(311)
	aq.	228.2	KOH; &	

Formula	State	Q, kj	Method	Lit
Hydrogen.—(*Continued*)				
H_2O	liq.	286.2	$H_2 + O_2$; &	(2, 16, 100.5, 165, 308, 322, 358.5, 459.5, 704, 890, 916, 970, 971, 976)
	gas	242.0	→liq.	(260, 461, 508,* 509,* 510,* 524,* 864, 865, 926)
H_2O_2	liq.	186.3	1.9^{15}_{200}	(389)
	gas	137.7	→liq.*	(251,* 651, 661.1,* 1066*)
	200	188.2	$+KMnO_4$; &	(72, 93, 146, 976)
	3.46	187.9	dil.	(389)
	2.53	187.8	dil.	
	1.00	186.9	dil.	
Fluorine				
F_2	gas	0	Def.	
F^-	aq.	327.3	KF	
HF(ideal)	gas	267.5	$H_2 + F_2$; &	(464, 465, 1032)
$(HF)_{2.5}$[HF at 745 mm]	gas	958.4	dissoc.*	923*)
HF	liq.	397	19	
				(464, 465)
	600	316.8	dil.	(157, 797
	400	316.2	$(HF_2)4S.4^{18}_{400}$	167, 1032
	200	316.2	dil.	464, 465
	12	316.2	dil.	
	6.5	315.8	dil.	
	2.2	314.3	dil.	
	1.7	312.8	dil.	
	0.5	307.6	dil.	
HF_2^-	aq.	624.4	KHF_2	
H_2F_2(ideal)	gas	1774	dissoc.*	(923*)
Chlorine				
Cl_2	gas	0	Def.	
	aq. (ideal)	30	aq.*	(548*)
	CCl_4	19.0	19.0^0	762
	aq.	22	aq.	(1052*)
Cl	gas	− 120.3	dissoc.*	(507,* 991,* 1033,* 1061,* 1062*)
Cl^-	aq.	165.55	HCl	599,* 988*
$Cl_2 \cdot 7H_2O$	c[10]	950	dissoc.*; &	393, 615,* 988*)
ClO^-	aq.	108	NaOCl	
ClO_2	liq.	− 126	→gas	582
	gas	− 98.3	dissoc.	223, 227, 692*
	aq.	− 70.7	27.6	223)
ClO_2^-	aq.	80	$NaClO_2$	
ClO_4^-	aq.	167	$KClO_4$	
Cl_2O	gas	− 76.4	$39.5^{25}_{\text{calc.}}$	976)
	aq.	− 36.9	$=HClO$	
[illegible]	c		Tr.: $1.23^{-174}_{(II)}$	348, 1088.5,
HCl	gas	92.2	$H_2 + Cl_2$; &	(2, 48.1, 484, 976)
(*see also* p. 212)	CCl_4	107.6	15.4^0	762)
	C_2H_5OH	136.4	44.4	
	∞	165.55	dil.	
	400	165.39	dil.	64, 745, 866,[9]† 976,[9]† 940,† 1003,† 1021[9]†
	200	165.16	73.0^{18}_{200}; &	158,[9] 643,* 760,* 976, 1021,[9] 1112)
	100	164.81	dil.	
	50	164.23	dil.	

Formula	State	Q, kj	Method	Lit.
Chlorine.—(*Continued*)				
HCl.—(*Continued*)	25	163.21	dil.	
	10	160.3	dil.	
	5	155.3	dil.	
	3	148.6	dil.	
	2	140.2	dil.	
	1	115.2	dil.	
HCl	In mixtures			(500,† 501*†)
$HCl.2H_2O$	c^{-18}	713	aq.	(83, 882)
HClO	200	124.6	+HI; &	(69, 976)
$HClO_3$	400	80	H_2SO_4 + $BaClO_3$	(77, 976)
$HClO_4$	liq.	81	85^{19}_{500}	(174)
	200	166	+KOH; &	(105, 976)
	96	165.8	dil.	(104)
	42	166.1	dil.	
	9.5	165.5	dil.	
	6	164.3	dil.	
	4.15	163.2	dil.	
	3.08	160.6	dil.	
	2.33	143.7	dil.	
	1.43	134.9	dil.	
	1	117	dil.	
$HClO_4.H_2O$	c	420	32	(104)
Bromine				
Br_2	liq.	0	Def.	
	gas	− 32.0	→liq.	(15.5, 168, 836,* 882,* 976)
	c	10.8	→liq.	(228,* 506,* 545,* 845, 846, 1048*)
	sat.	3	3*	(1048*)
	aq.(ideal)	5	5	(126, 811, 976)
Br	gas	− 111.7	dissoc.*	(210,* 599,* 788,* 789*)
Br^-	aq.	119.7	HBr	
Br_3^-	aq.	130	HBr_3	
Br_5^-	aq.	149	HBr_5	
BrO^-	aq.	91	KBrO	
BrO_3^-	aq.	51	$HBrO_3$	
$HBr_{(I)}$	c		Tr. $0.692^{-107}_{(II)}$	(348)
$HBr_{(II)}$	c		Tr. $0.473^{-183}_{(III)}$	(348)
HBr	gas	36.2	83.2^{18}_{200}	(64, 976)
HBr	∞	119.7	extrap.	
	400	119.6	dil.	
	200	119.4	Br_2 + KCl; &	(48.1, 81, 976)
	100	119.3	dil.	(64, 883, 976)
	50	118.9	dil.	
	25	118.3	dil.	
	10	115.9	dil.	
	6	112.4	dil.	
	5	109.7	dil.	
	3	102.6	dil.	
	2	94	extrap.	
$HBr.2H_2O$	c^{-15}	688	dissoc.; &	(64, 883*)
HBr_3	200	130	Br_2 + HBr; &	(648*)
HBr_5 (?)	∞	149	Br_3^- + $Br_{(aq.)}$	(648*)
HBrO	aq.	107	N = HClO	
$HBrO_3$	200	53	+$SnCl_2$; &	(81, 976)
Iodine				
I	c	0	Def.	
I_2	gas	− 63	c*	(34,* 359)
	liq.^{114}	− 20	→gas*	(34*)
	aq.(ideal)	− 23	−23*	(502,*° 904†)
I	gas	− 106.59	dissoc.*	(200, 231, 599,* 641.1,* 937,* 1061*)
I^-	aq.	55.8	HI	
I_3^-	aq.	91	HI_3	
IO_3^-	aq.	227	KIO_3	(904*)
IO_6^{---}	aq.	610	K_3IO_6	
I_2O_5	c	176.0	-7.5^{18}_{1500}	(82, 314, 976)
$III_{(I)}$	c		Tr.: $0.526^{-194}_{(III)}$	(348)
$III_{(II)}$	c		Tr.: $0.295^{-221}_{(III)}$	(348)

Formula	State	Q, kj	Method	Lit.
Iodine.—(*Continued*)				
HI	gas	− 24.8	80.5^{18}_{200}; &	(138, 300, 939,* 976)
	∞	55.8	extrap.	
	200	55.7	HCl + PbI_2; &	(81, 976)
	100	55.6	dil.	(64, 976)
	50	55.4	dil.	
	20	54.8	dil.	
	10	53.0	dil.	
	5	48.0	dil.	
	3	37	dil.	
	2	28	dil.	
HI_3	aq.	91	I_2 + HI; &	(1034)
HIO	aq.	95	N = HClO	
HIO_3	c	236.0	−9.0	(82, 314, 976)
	aq.	227	HI + KIO_3	(80, 81, 925,* 976)
HIO_4	aq.	190	$=H_5IO_6$	
HIO_6^{---}	aq.	663		
$H_2IO_6^{--}$	aq.	716	$K_3H_2IO_6$	
$H_3IO_6^-$	aq.	761	$K_2H_3IO_6$	
$H_4IO_6^-$	aq.	729	KH_4IO_6	
H_5IO_6	c	772	-5.8^{18}_{2000}	(976)
	aq.	766	+$SnCl_2$; &	(976)
$2HIO_3.I_2O_5$	c	353	-23.9^{12}_{1700}	(82)
$ICl_{(\alpha)}$	c	28	I + Cl; &	(94)
$ICl_{(\beta)}$	c	27	→(α)	(951, 963)
ICl	liq.	19	→(α)	(951, 963, 976)
ICl_3	c	70	I + Cl; &	(94)
IBr	liq.	11	I + Br	(94)
	gas	− 40	dissoc.*	(214,* 738*)
Sulfur				
$S_{(rhom.)}$	c	0	Def.	
$S_{(monocl.)}$	c	− 0.29	Tr.; 0.29	(240,* 642, 702, 956*)
$S\lambda$	liq.	− 1.6	→$S_{(rhom.)}$	(642)
$S\mu$	liq.	− 3.3	→$S\lambda$	(642,* 730)
	gas	− 162	dissoc.*	(641.1*)
$S^=$	aq.	− 42	Na_2S	
S_2	gas	[illegible] 124	dissoc.*	(641.1*)
$S_2^=$	aq.	− 40	Na_2S_2	
$S_3^=$	aq.	− 33	Na_2S_3	
$S_4^=$	aq.	− 27	Na_2S_4	
S_6	gas	− 95	dissoc.*	(831*)
S_8	gas	− 84	dissoc.*	(831,* 1077)
SO_2	gas	290	S + O_2; &	(97, 428.1, 976)
	liq.	315.0	→gas	(265, 344, 345, 672)
	2000	325.8	35.8	(345, 646,* 647,* 942, 976)
	1000	324.5	34.4	
	500	323.0	33.0	
	200	321.2	31.2	
	100	319.8	29.8	
	75	319.2	29.2	
$SO_2^=$	aq.	468	Na_2SO_3	
SO_3 (ice form)	c	432	156	(52, 450.5, 932*)
	liq.	423	163.9^{20}_{1600}	(450.5, 976)
	gas	383	206	(98, 450.5)
	200	582	$= H_2SO_4$	
$SO_3^=$	aq.	614.4	K_2SO_3	
$SO_4^=$	aq.	885.0	K_2SO_4	
$S_2O_3^=$	aq.	590	$Na_2S_2O_3$	
$S_2O_4^=$	aq.	665	$Na_2S_2O_4$	
$S_2O_5^=$	aq.	948.7	$= HSO_3^-$	
$S_2O_6^=$	aq.	1148	$Na_2S_2O_6$	
S_2O_7	c	356(?)	+ aq.	(448)
$S_2O_8^=$	aq.	1296	$K_2S_2O_8$	
$S_4O_6^=$	aq.	1093	$Na_2S_4O_6$	

Formula	State	Q, kj	Method	Lit.
Sulfur.—(*Continued*)				
$S_4O_6^=$	aq.	1096	$Na_2S_4O_6$	
$S_3O_6^=$	aq.	1120	$K_2S_3O_6$	
HS^-	aq.	15	KHS	
H_2S	gas	22	$+I_2$; &	(641.1,* 823, 976)
	liq.	40	gas	(424*)
	aq.	41.3	19.1; &	(976, 1052*)
$H_2S.7H_2O$	c^{-30}	1670	dissoc.*	(257,* 424,* 897*)
$H_2S_5 + S_x$	liq.	10	$+I_{(aq.)}$	(897)
HSO_3^-	aq.	617.3	$KHSO_3$	
HSO_4^-	aq.	878	$KHSO_4$	
H_2SO_2	aq.	463	$N = H_2SO_3$	
H_2SO_3	200	607.2	$=SO_{2(aq.)}$	
H_2SO_4	liq.	794.1	74.3^{18}_{200}	(243)
(*see also* p. 212)	c	804.5	+ aq.	(56, 243, 498)
	∞	880.0	$=SO_4^=$	
	1599	873.6	dil.	
	799	871.6	dil.	
	399	869.8	dil.	
	199	868.4	N, Na_2SO_4; &	(50, 53, 843, 976°)
	99	867.8	dil.	(138,† 243,*°
	49	866.8	dil.	358, 458,
	19	864.9	dil.	672, 748,°
	9	859.5	dil.	803, 812,
	8	858.0	dil.	890,† 976°)
	7	856.4	dil.	
	6	854.3	dil.	
	5	851.3	dil.	
	4	847.9	dil.	
	3	843.1	dil.	
	2	835.9	dil.	
	1.5	830.9	dil.	
	1.0	822.1	dil.	
	0.5	809.7	dil.	
$H_2SO_4.H_2O$	liq.	1108.3	aq.	(243)
	c	1127.6	aq.	(57, 243)
$H_2S_2O_3$	1500	580	$Na_2S_2O_3$ + HCl	(976)
$H_2S_2O_4$	aq.	659	$N = H_2SO_3$	
$H_2S_2O_6$	400	1148	N, $Na_2S_2O_6$	(745, 976)
$H_2SO_4.SO_3$	liq.	1230	aq.	(243)
	c	1241.0	→ liq.	(1076)
$H_2S_2O_8$	aq.	1297	$+FeSO_4$; &	(135)
$H_2S_3O_6$	aq.	1096	$N = H_2S_2O_5$	
$H_2S_4O_6$	aq.	1098	$N = H_2S_2O_6$	
$H_2S_5O_6$	aq.	1120	$N = H_2S_2O_6$	
S_2Cl_2	gas	23.6	→liq.	(504,* 770)
	liq.	60	S + Cl	(770, 976)
SCl_4	liq.	60+	$S_2Cl_2 + Cl_2$	(17, 36)
$SOCl_2$	gas	174	→liq.	(770)
	liq.	201	164_{KOH}	(770, 771)
SO_2Cl_2	gas	338	→liq.	(771, 1109)
	liq.	367	263_{300}	(770, 771, 976)
$S_2O_5Cl_2$	liq.	677	+KOH	(770, 771)
	gas	623	→liq.	(770, 771)
$SO_3.HCl$	liq.	583	$SO_3 + HCl$	(772)
S_2Br_2	liq.	8.4	S + Br	(770, 795)
S_2I_2 (?)	c	0.0	S + I	(770)
Selenium				
$Se_{(\gamma)(insoluble)}$	c	0	Def.	
$Se_{(\alpha)\ (soluble)}$	amorp.	− 6.0	$+Cl_2$; &	(730.1, 795)
$Se_{(\beta)\ (soluble)}$	c	− 1.6	$+Cl_2$; &	(730.1, 795)
$Se_{(rapidly\ cooled)}$	gls.	− 4	$+Cl_2$; &	(795)
Se_2	gas	146	Se_γ	(317)
$Se^=$	aq.	− 112	Na_2Se	
SeO_2	c	236.1	−3.8	(549, 976)
	aq.	232	$SeCl_4 + H_2O$; &	(976)
$SeO_3^=$	aq.	515	Na_2SeO_3	
$SeO_4^=$	aq.	613	Na_2SeO_4	
HSe^-	aq.	− 154	KHSe	

Formula	State	Q, kj	Method	Lit.
Selenium.—(*Continued*)				
H_2Se	gas	− 66	+I; &	(208,* 350, 785.5,* 878*)
	aq.	− 56.1	10^{18}	(350, 424,* 878,* 1101)
$H_2Se + XH_2O$	c	$4 + XH_2O$	dissoc.*	(424*)
$HSeO_3^-$	aq.	522	$NaHSeO_3$	
$HSeO_4^-$	aq.	604	$NaHSeO_4$	
H_2SeO_3	c	535.8	−17.2	(549)
	aq.	518.6	$=SeO_{2(aq.)}$	
H_2SeO_4	liq.	530	70_{400}	(696)
	c	545	55.9_{400}	(696)
	200	600	dil. $= H_2SO_4$	
	1000	603	$SeO_2 + HClO$; &	(976)
$H_2SeO_4.H_2O$	c	856	31.2_{400}	(696)
	liq.	837	51_{400}	(696)
Se_2Cl_2	liq.	92.7	$Se + Cl_2$	(976)
$SeCl_4$	c	193.2	$Se + Cl_2$	(976)
$SeO_2.SO_3$	c	683	134.4^{15}_{4000}	(696)
Tellurium				
$Te_{(metallic)}$	c	0	Def.	
$Te_{(amorphous)}$	amorp.	− 11.4	$+Br_2$	(302, 351, 915)
TeO_2	c	327.7	$Te + 2H_2O$*	(711, 915)
	aq.	320	$TeCl_4 + H_2O$	(976)
$TeO_2.H_2O$	c	606	0	(975)
TeO_3	c	348	$+Na_2O$	(711)
$TeO_3^=$	aq.	580	K_2TeO_3	
$TeO_4^=$	aq.	722	K_2TeO_4	
H_2Te	gas	− 142	$+FeCl_3$; &	(351)
H_2TeO_4	aq.	708	$TeO_2 + Br$; &	(351, 976)
$H_2TeO_4.2H_2O$	c	1294	-14.0^{14}_{600}	(696)
$TeCl_4$	c	324	$Te + Cl_2$	(976)
$TeBr_4$	Br_2	278	$Te + Br_2$	(351)
$2TeO_2.SO_3$	c	1280	257^{18}_{KOH}	(696)
Nitrogen				
N_2	gas	0	Def.	
N	gas	− 540	dissoc.*	(197.5)
$N_{3(l)}$	c		Tr.; $0.22^{-237.6}_{(II)}$	(346)
N_3^-	aq.	− 245	BaN_6	
NO	gas	− 90	$NO + C_2N_2$; &	(71, 90, 755,* 976)
N_2O	gas	− 71	+CO; &	(90, 954, 976)
	liq.	− 78.4	→gas	(672)
$N_2O.6H_2O$	c^0	1692	dissoc.*	(1016*)
NO_2	$gas_{(ideal)}$	− 31.1	$NO + O$;* &	(212,* 641.1*)
NO_2^-	aq.	107	$NaNO_2$	
NO_3^-	aq.	208.4	HNO_3	
$N_2O_2^=$	aq.	− 15	$Na_2N_2O_2$	
N_2O_4	$gas_{(ideal)}$	− 7.8	dissoc.; &	(71, 209,* 911,* 1068*)
	liq.	21	$+Cl_2$; &	(71, 994.5)
	c^{-10}	33.6	→liq.	(835)
N_2O_5	gas	5	124.7^{10*}	(55, 303*)
	c	61	69.8^{10}_{400}	(55)
NH_3	gas	45.8	dissoc.; &*	(485, 486, 487,* 488, 955)
(*see also* p. 213)				
	liq.	66.3	→gas	(733, 848, 952)
	200	81.3	35.4^{18}_{200}	(33, 66, 359, 976, 1021)
	50	81.2	dil.	(66, 976)
	25	81.1	dil.	
	15	81.0	dil.	
	3.2	79.7	dil.	
	1.0	75.9	dil.	
NH_4^+	aq.	132.7	NH_4Cl	
N_2H_4	aq.	− 13.6	$N_2H_4.H_2SO_4$ $+Ba(OH)_2$	(21, 1094)
$N_2H_4H^+$	aq.	27	$N_2H_4.HCl$	
$N_2H_4H_2^{++}$	aq.	27	$N_2H_4.2HCl$	
HN_3	aq.	− 228	N	(163)
$NH_3.HN_3$	c	− 84	dissoc.	(163)
	aq.	− 113	-28.2^{17}_{500}	(21, 163)

Formula	State	Q, kj	Method	Lit.
Nitrogen.—(*Continued*)				
HNO_2	200	121	$NaNO_2$ + HCl	(71, 954)
HNO_3	gas	147.9	liq.	(55)
	liq.	177.3	30.0^{10}	(55)
	∞	208.4	extrap.	
	400	208.41	→dil.	
	200	208.37	$HNO_3 + Cl_2$; &	(71)
	100	208.43	dil.	(63, 867,° 976)
	50	208.52	dil.	
	25	208.67	dil.	
	20	208.5	dil.	
	10	207.9	dil.	
	5	205.2	dil.	
	3	201.2	dil.	
	2	197.3	dil.	
	1	191.0	dil.	
	0	177.3	dil.	
NH_2OH	aq.	87	NH_2OH + HCl; &	(79, 330, 976)
NH_4OH	200	367.5	= NH_3 aq.	
$NH_2OH.H^+$	aq.	126	$NH_2OH.HCl$	
NH_4NO_3	c	260.1	-19.9^{12}_{400}; &	(71, 976)
	400	240.6	N	(71, 976)
NH_4NO_3(IV)	c	368.0	-26.5^{18}_{200}	(54, 459, 729,° 976, 981,° 1046°)
NH_4NO_3(V)	c		Tr.; $-0.5^{-18}_{(IV)}$	(19, 45.4, 234,* 286 729)
NH_4NO_3(III)	c		Tr.; $1.67^{32}_{(IV)}$	(45.1, 234,* 728, 1083.5)
NH_4NO_3(II)	c		Tr.; $1.3^{83}_{(III)}$	(45.1, 234*)
NH_4NO_3(I)	c		Tr.; $4.3^{25}_{(II)}$	(45.1, 234*)
(*see also* p. 162)	∞	340.9	extrap.	
	1000	341.05	dil.	
	500	341.16	dil.	
	200	341.58	N	(78, 976)
	100	342.01	dil.	(286, 325,† 629,° 729, 827,° 976, 981°)
	50	342.97	dil.	
	25	344.70	dil.	
	20	345.0	dil.	
	10	346.8	dil.	
	5	349.4	dil.	
	3	350.7	dil.	
	2.5	352.4	dil.	
$NH_2OH.HNO_3$	c	359	$+O_2$	(151)
	aq.	334	-25^{12}_{300}	(151)
$H_2N_2O_2$	aq.	35	$Na_2N_2O_2$	(133)
N_2H_4HOH	c	264.7	8.0^{18}_{400}	(21)
	aq.	272.7	= N_2H_4 aq.	
$N_2H_4.HNO_3$	aq.	235.7	N	(21)
$N_2H_4.2HNO_3$	aq.	443.9	N	(21)
NH_4F	c	467.5	−6.3	(464)
	aq.	461.2	N	(464, 465, 976)
NCl_3	CCl_4	− 229.5	+HCl; &	(762, 903)
NOCl	gas	− 53.0	+KOH; &	(238, 641.1,* 953,* 986,* 989,* 990,* 992,* 1005.1*)
NH_4Cl(I)	c		Tr.; $4.2^{184}_{(II)}$	(235,* 905,* 1037*)
NH_4Cl(II)	c	314.2	-16.3^{18}_{200}; &	(9, 49, 54, 295,° 313,† 623,° 729, 834, 890,† 934,† 976, 1046°)
NH_4Cl(III)	c		Tr.; $-1.5^{-31}_{(II)}$	(349, 922)
NH_4Cl	∞	298.3	dil.	
(*see also* p. 161)	1000	298.13	dil.	
	500	298.04	dil.	

Formula	State	Q, kj	Method	Lit.
Nitrogen.—(*Continued*)				
NH_4Cl.—(*Continued*)	200	297.90	N	(49, 50, 976°)
	100	297.84	dil.	(653,† 827,° 976)
	50	297.88	dil.	
	25	298.08	dil.	
	10	300.2	dil.	
$N_2H_4.HCl$	c	214 7	-22.8^{17}_{500}	(21)
	aq.	192.0	N; &	(21)
$N_2H_4.2HCl$	c	383.0	-25.9^{19}_{500}	(21)
	aq.	357.0	$BaCl_2$ + $N_2H_6SO_4$; & analogy	(21, 163)
$NH_4Cl.3NH_3$	c	560		
$NH_4Cl.6NH_3$	c	805	dissoc.*	(225, 994*)
$NH_2OH.HCl$	c	304.5	-13.8^{24}_{450}	(79)
	400	290.6	N	(79, 330, 976)
NH_4ClO_4	c	327.7	-26.6^{20}_{220}	(104)
	aq.	301	N	(104)
NOBr	gas	− 73.4	→gas	(987*)
	liq.	− 47	+KOH; &	(987*)
$NOBr_3$	gas	− 20	→liq.	(987*)
	liq.	+ 7	+KOH; &	(987*)
NH_4Br(II)	c	270.8	-18.6^{18}_{200}	(11, 562,* 929,† 976)
NH_4Br(I)	c		Tr.; $3.2^{138}_{(II)}$	(235*)
	200	252.2	N	N = HCl
NH_4I(I)	c		Tr.; $2.9^{-18}_{(II)}$	(235*)
NH_4I(II)	c	203.2	-14.9^{18}_{200}	(976)
	200	188.3	N	
NS	c	− 133	dissoc.	(174)
$N_2O_3(SO_3)_2$	c	948	$477^{22}_{KOH(200)}$	(1110)
NH_4HS	c	163	−14	(56, 237, 541,* 542,* 656,* 1025*)
	aq.	149.3	NH_3 + $(NH_4)_2S$	(56, 976)
$(NH_4)_2S$	200	231.2	N	(56, 976)
NH_4S_2	c	135	$+I_2$	(897)
	aq.	117	-18^{13}_{150}	(897)
NH_4S_4	c	133	$+I_2$	(897)
	aq.	115	−18	(897)
$(NH_4)_2S_5$	c	271	$+I_2$	(897)
	aq.	235	-36^{13}_{1000}	(897)
NH_4HSO_3	aq.	750	= $(NH_4)_2S_2O_5$	(378)
NH_4HSO_4	c	1006.2	-0.1^{18}_{200}	(976)
	800	1008.5	dil.	
	400	1007.2	$(NH_4)_2SO_4$ + H_2SO_4	(50, 976)
	200	1006.1	dil.	(976)
	100	1005.3	dil.	
	50	1004.8	dil.	
	20	1004.3	dil.	
	10	1002.8	dil.	
$NH_2OH.H_2SO_4$	aq.	1001	N	(79, 330)
$N_2H_4.H_2SO_4$	c	939	$+O_2$	(79)
	aq.	903	-35.7^{19}_{1200}	(21)
$(NH_4)_2SO_3$	c	879.7	-6.4^{18}_{440}	(378)
	aq.	873.4	N	(378)
$(NH_4)_2SO_3.H_2O$	c	1178	-18.2^{13}	(378, 503)
$(NH_4)_2SO_4$	c	1162.0	-10.0^{18}_{400}	(976)
	400	1152.1	N	(50, 224, 976°)
	200	1152.4	dil.	(976)
	100	1152.9	dil.	
	50	1153.7	dil.	
	30	1154.5	dil.	
	10	1155.6	dil.	
$(NH_2OH)_2.H_2SO_4$	c	1158	-24.3^{13}_{900}	(79)
	aq.	1133	N	
$(NH_4)_2S_2O_5$	c	1240	-26^{8}_{440}	(378)
	aq.	1314	N	(378)
$(NH_4)_2S_2O_8$	c	1602	-38^{18}_{1000}	(1350)
	aq.	1563	N	(1350)
NSe	c	− 177	dissoc.	(175)
NH_4HSe	c	102	-21^{18}_{1500}	(350)
	aq.	82	N	(350)
$(NH_4)_2Se$	aq.	163	N	(350)

Formula	State	Q, kj	Method	Lit.
Phosphorus[a]				
$P_{(white)}$	c	0	Def.	
$P_{(red)}$	c	18	$+Br_2$?; &	(354, 447, 995*)
P_2	CS_2	− 3.8	-3.8_{CS_2}	(768)
PO_3^-	aq.	984	$NaPO_3$	
PO_4^{---}		1250	Na_3PO_4	
P_2O_5	c	1531	$P + O_2$	(447)
	amorp.	1535.4	→c	(308, 447)
	gls.	1555.1	→c	(447)
$P_2O_7^{----}$	aq.	2246	$Na_4P_2O_7$	
P_2H	c	50	$+Br_2$	(628, 768)
PH_3	gas	− 25	$+O_2$; &	(628, 768)
HPO_3	c	941.2	40.8	(447)
	aq.	981.4	$+H_2O$	(447)
HPO_3^-	aq.	961	Na_2HPO_3	
HPO_4^{--}	aq.	1287	Na_2HPO_4	
$H_2PO_2^-$	aq.	596	NaH_2PO_2	
$H_2PO_3^-$	aq.	962	NaH_2PO_3	
$H_2PO_4^-$	aq.	1285	NaH_2PO_4	
H_3PO_2	liq.	581.8	9.1^{19}_{150}	(976)
	c	591.6	-0.7^{12}_{160}	(976)
	450	591.8	dil.	
	250	590.9	$BaH_4P_2O_4 + H_2SO_4$	(976)
	220	590.8	dil.	(797)
	110	588.8	dil.	
	55	587.8	dil.	
H_3PO_3	liq.	945.2	12.3^{19}_{150}	(976)
	c	958.1	0.5^{19}_{150}	(976)
	aq.	957	$+Br_2$	(976)
H_3PO_4	liq.	1258.6	22.4^{20}_{200}	(976)
	c	1268.6	11.3^{19}_{150}	(566, 976)
	400	1281.3	dil.	
	200	1281.0	P_2O_5 + aq.	(447, 976)
	100	1280.7	dil.	(566, 797, 890, 976)
	50	1280.3	dil.	
	20	1279.3	dil.	
	9	1277.5	dil.	
	3	1272.4	dil.	
	1	1265.9	dil.	
$H_3PO_4.\frac{1}{2}H_2O$	liq.	1439.6	15.8	(566)
$HP_2O_7^{===}$	aq.	2260	$Na_3HP_2O_7$	
	c	1424.7	0.6	
$H_2P_2O_5^{--}$	aq.	1608	$Na_2H_2P_2O_5$	
$H_2P_2O_7^{--}$	aq.	2261	$Na_2H_2P_2O_7$	
$H_3P_2O_7^-$	aq.	2260	$NaH_3P_2O_7$	
$H_4P_2O_5$	aq.	1608	N	(8)
$H_4P_2O_6$	c	− 31.4 +	31.4^{11}_{250}	(567)
	aq.	Q		
$H_4P_2O_6.2H_2O$	c	581.5 + Q	-2.2^{10}_{350}	(567)
	liq.	545 + Q	→c	(567)
$H_4P_2O_7$	liq.	2215.4	42.8	(447)
	c	2224.9	33.5	(447)
	aq.	2258.1	$+H_2SO_4$; &	(447)
$H_4P_2O_7.1\frac{1}{2}H_2O$	liq.	2655	31.9	(449, 450)
	c	2668	18.8	(449, 450)
PCl_3	gas	293	→liq.	(14, 847)
	liq.	322	272.6^{19}_{1000}	(159, 976)
PCl_5	c	446	516.6^{22}_{1000}	(2, 15, 976)
$POCl_3$	liq.	615.8	302.1^{20}_{1000}	(159, 976)
$PH_3.HCl$	c	130	$HCl + PH_3$	(237)
PBr_3	liq.	190	$+H_2O$; &	(159, 237, 447)
PBr_5	c	254	P + Br	(769)
$POBr_3$	c	447	$+H_2O$	(769)
$PH_3.HBr$	c	107	−12.7	(767, 768)
PI_3	c	46	P + I	(769)
	CS_2	59	14_{CS_2}	(769)
P_2I_4	c	83	$+H_2O$	(769)
$PH_3.HI$	c	50.5	−20	(767, 768)

[a] Heat of mixing $H_3PO_4 + HPO_3$ (29); $P_4 = P_2$ (g) (830, 943); $PF_3 + KOH$: ΔQ = 450.7 (forms a fluorophosphoric acid) (125).

Formula	State	Q, kj	Method	Lit.
Phosphorus.—(*Continued*)				
P_3N_5	c	314	$+O_2$	(945)
$NH_4H_2PO_4$	aq.	1419	N	(162)
$(NH_4)_2HPO_4\alpha$				
$= \frac{(NH_4)_2}{H} > PO_4$	aq.	1553	N	(162)
$(NH_4)_2HPO_4\beta$				
$= (NH_4)_2(HPO_4)$	aq.	1540	N	(162)
$(NH_4)_3PO_4$	aq.	1664	N	(162)
Arsenic				
As	c	0	Def.	
$As_{(black)}$	amorp.	0	$+Cl_2$	(521, 795)
$As_{(brown)}$	amorp.	− 15	$+Cl_2$	(177,* 795)
AsO_4^{---}	aq.	874	Na_2AsO_4	
As_2O_3(opaque)	c	654	$-31.5^{18}_{4NaOH(100)}$	(976)
As_2O_3(monoclinic)	c	619	$\rightarrow As_2O_3$(octa.)	(896,* 1043*)
As_2O_3(octahedral)	c	645	$H_2 + As_2O_3$*	(914*)
	aq.	622	$AsCl_3 + H_2O$; &	(48.1, 976)
As_2O_5	c	911.9	25.1	(710, 976)
	aq.	937	As + Br + H_2O; &	(155, 976)
As_4O_6	gas	1121	$\rightarrow As_2O_3$(mono)	(896,* 925.1,* 941.1,* 1043*)
AsH_3	gas	− 182	$+Br_2$	(766, 768)
$AsH_3.6H_2O$	c^{-10}	1535	dissoc.[3]	(420*)
$HAsO_3^-$	aq.	656	Na_2HAsO_3	
$HAsO_4^{--}$	aq.	897	Na_2HAsO_4	
$H_2AsO_3^-$	aq.	711	NaH_2AsO_3	
$H_2AsO_4^-$	aq.	902	NaH_2AsO_4	
H_3AsO_3	aq.	740	$= As_2O_3$ aq.	
H_3AsO_4	c	899.7	-1.7^{18}_{300}; &	(976)
	aq.	898	$= As_2O_5$ aq.	
$AsCl_3$	c	303	As + Cl_2; &	(84, 795, 976)
	liq.	182.0	$\rightarrow c^{32}$	(984)
$AsBr_3$	c	194	250^{9}_{KOH}	(84)
	liq.	182	→c	(983)
AsI_3	c	60	193^{9}_{KOH}	(84)
As_2S_2	c	80	$+H_2$*	(553*)
Antimony				
$Sb_{(I)}$	c		Tr.; $0.2^{630}_{(II)}$	(610)
$Sb_{(II)}$	c	0	Def.	
$Sb_{(explosive)}$	c	− 9.9	$+Br_2$; &	(288)
SbO_4^{---}	aq.	883	Na_3SbO_4	
Sb_2O_3(prism)	c	692	$42_{7HF(100)}$	(464, 465, 710)
Sb_2O_3(ordinary)	c	692	$42_{7HF(100)}$	(322, 465)
Sb_2O_3(octahedral)	c	697	Na_2O_2; &	(465, 710)
	aq.	537	$= H_2SbO_2$	
Sb_2O_4	c	884	$+Na_2O_2$	(710)
Sb_2O_5	c	966	$+Na_2O_2$	(710)
	aq.	954.0	$= H_3SbO_4$	
SbH_3	gas	− 145.7	dissoc.; &	(170, 946)
H_3SbO_3	aq.	698	$SbCl_3 + H_2O$; &	(464, 976)
H_3SbO_4	aq.	906.3	$SbCl_5 + H_2O$; &	(976)
SbF_3	c	906	-7_{200}	(464, 465)
	aq.	899	$Sb_2O_3 + HF$	(464, 465)
H_3SbF_6	aq.	1856.0	$SbF_3 + HF$	(464, 465)
$SbCl_3$	c	382.5	Sb + Cl_2	(464, 976)
	liq.	369.5	→c	(982, 984)
$SbCl_5$	c	449.1	→liq.*; &	(35,* 722)
	liq.	438.9	$SbCl_3 + Cl_2$; &	(464, 976)
	gas	392.6	→liq.	(232)
$SbOCl$	c	373.3	+HF	(464, 465)
Sb_4O_5Cl	c	1448	+HF	(464, 465)
$SbBr_3$	c	257	+HF	(170, 466)
	liq.	243.9	→c	(984)
	CS_2	242	$15^{25}_{CS_2}$	(288)
SbI_3	c	185	+HF	(466)
Sb_2S_3(orange)	c	149	$+Na_2S$; &	(127)

Formula	State	Q, kj	Method	Lit.
Antimony.—(*Continued*)				
$Sb_2S_{3(black)}$	c	150	$+Na_2S$; &	(127, 463, 553,* 786*)
$Sb_2S_{3(lilac)}$	(?)	132	$+Na_2S$; &	(127, 463)
$Sb_2S_{3(brown)}$	(?)	155	$+Na_2S$; &	(127, 463)
Bismuth				
Bi	c	0	Def.	
Bi_2O_3	c	567	$+Na_2O_2$	(710)
$Bi_2O_3.XH_2O$	ppt.	572+ X286	$BiCl_3$ + NaOH; &	(976)
H_3BiO_3	aq.	716	$= Bi_2O_3.XH_2O$	
$BiCl_3$	c	379.2	$Bi + Cl_2$	(976)
BiOCl	c	367	$BiCl_3 + H_2O$	(759,* 976)
Bi_2S_3	c		dissoc.*	(553,* 786*)
Carbon[a]				
$C_{(\beta\ graph.)}$	c	0	Def.	
$C_{(ordinary\ graphite)}$	gas	− 638	c	(586, 587, 588)
$C_{(\alpha\ graph.)\ (low\ temp.)}$	c	1.0	$+O_2$	(886, 887)
$C_{(diamond)}$	c	− 0.7	$+O_2$	(885, 886, 887)
$C_{(acetylene)}$	amorp.	− 2.0	$+O_2$; &	(705)
$C_{(gas\ carbon)}$	amorp.	− 2	$+O_2$	(885)
$C_{(charcoal)\ (H-free)}$	amorp.	− 2	$+O_2$	(885)
$C_{(sugar)}$	amorp.	− 10	$+O_2$	(705)
$CO_{(l)}$	c		Tr.; $0.60^{-212.7}_{(l)}$	(346)
CO	gas	110.6	$+O_2$; &	(81, 90, 322, 551,* 906,* 976, 1102*)
	sat.	125.0	14.4*	(1049*)
CO_2	gas	395.0	$C + O_2$	(308, 885, 886, 887)
	sat.	414.9	19.9	(3, 53, 218,* 976)
$CO_{2(on\ charcoal)}$		426	$CO_2 + C$	(654)
$CO_2.6H_2O$	c[10]	1779	dissoc.*	(1016*)
$CO_3^=$	aq.	674	Na_2CO_3	(958*)
$C_2O_4^=$	aq.	816.9	$K_2C_2O_4$	
CH_4	gas	80	$+O_2$	(165, 976)
C_2H_2	gas	− 227.4	$+O_2$; &	(705)
	aq.	− 210	17; &	(153, 1016, 1053*)
$C_2H_2.6H_2O$	c[9]	981	dissoc.	(1015*)
C_2H_4	gas	− 40	$+O_2$	(709, 976)
C_2H_6	gas	98	$+O_2$	(165, 976)
HCO_2^-	aq.	414	$NaHCO_2$	
HCO_3^-	aq.	689.1	dissoc.*; &	(578*)
$HCHO_2$	c	426	-9.8^{7}_{300}	(56, 800, 957)
	liq.	415.2	$+O_2$; &	(164, 976)
	gas	394.0	→liq.	(250.5, 358.1)
	200	415.8	0.7^{18}_{100}	(68, 352, 976)
	100	415.8	dil.	
	50	415.7	dil.	
	2	415.9	dil.	
	1	415.9	dil.	
	0.5	415.6	dil.	
H_2CO_3	aq.	701.1	$= CO_2$ aq.	
$CH_3OH_{(l)}$	c		Tr.; $0.58^{-112}_{(l)}$	(778)
CH_3OH	liq.	251.1	$+O_2$	(861, 948)
(*see also* p. 162)	gas	213.0	→liq.	(250.5, 546.5, 667.5, 904.5, 1003.5, 1053.5)
	aq.	259	8.4	(75)
	33.8	258.0	dil.	(223.5)
	16.0	257.7	dil.	
	7.11	256.6	dil.	
	4.15	255.4	dil.	
	2.67	254.4	dil.	
	1.19	252.9	dil.	
	0.44	252.0	dil.	
$HC_2O_4^-$	aq.	814.8	$NaHC_2O_4$	
$H_2C_2O_4$	c	824.6	$+O_2$; &	(56, 949, 976, 1013)

[a] For other compounds of carbon, *see* the section on Heats of Combustion, p. 162. For various reactions in C_2H_5OH, *cf.* (309, 311).

Formula	State	Q, kj	Method	Lit.
Carbon.—(*Continued*)				
$H_2C_2O_4$.—(*Continued*)	gas	734.0	→c*	(763*)
	aq.	814	-9.5^{18}_{300}; &	(56, 68, 976)
$H_2C_2O_4.2H_2O$	c	1422	-35.9^{20}_{300}	(56, 459, 571, 571.5, 976)
$C_2H_2O_2^-$	aq.	492	$NaC_2H_3O_2$	
$HC_2H_3O_2$	c[7]	503	-9.0^{7}_{150}	(49, 68, 235,* 800)
	liq.	492.6	$+O_2$	(164, 838)
	gas	471.4	→liq.	(250.5, 668.5, 1072)
	200	494.1	dil.	(158,° 352, 976)
	100	494.0	dil.	
	50	493.7	dil.	
	20	493.3	dil.	
	8	492.6	dil.	
	4	492.1	dil.	
	2	491.9	dil.	
	1.5	491.9	dil.	
	1.0	491.9	dil.	
	0.5	492.0	dil.	
$C_2H_5O^-$	C_2H_5OH	264	NaC_2H_5O	
C_2H_5OH	gas	233.5	→liq.	(904.5, 1053.5, 1072†)
(*see also* p. 162)	liq.	275.8	$+O_2$	(15.5, 20, 164, 546.5, 650.5, 848, 861)
	200	286.99	dil.	(75, 223.5°,
	100	286.50	dil.	326, 652,[1]
	50	286.35	dil.	827°)
	25	285.8	dil.	
	10.2	284.0	dil.	
	5.94	281.8	dil.	
	3.84	279.8	dil.	
	1.70	277.5	dil.	
	0.64	276.4	dil.	
	0.28	276.1	dil.	
$C_4H_4O_6^=$	aq.	1239	$K_2C_4H_4O_6$	
$HC_4H_4O_6^-$	aq.	1245	$KHC_4H_4O_6$	
$H_2C_4H_4O_{6(d\ or\ l)}$	c	1263	$+O_2$	(776)
$H_2C_4H_4O_{6(meso)}$	c	1269.5	−21.9	(71)
$(H_2C_4H_4O_6)_{2(dl)}$	c	2541	−45.4	(71, 962)
$H_2C_4H_4O_{6(d,\ l,\ or\ dl)}$	400	1247.5	-15.1^{19}	(54, 71, 976)
	200	1247.7	dil.	
	100	1247.8	dil.	
	50	1248.0	dil.	
	20	1248.6	dil.	
	6	1248.9	dil.	
CCl_4	c		Tr.; $5^{-48.5}_{(l)}$	(613)
	gas	106.3	$+H_2$; &	(211.5, 976)
	liq.	138.9	→gas	(667.5, 848, 1003.5, 1053.5, 1072)
$COCl_2$	gas	218	$-O_2$; &	(18,* 85, 211,* 213, 526,* 641.1,* 782,* 976)
	liq.	242.7	→gas	(441†)
$COBr_2$	gas	92	dissoc.*	(958*)
$(CS)_x$	c	$-(54)_x$	$+O_2$	(1086)
CS_2	gas	− 120	liq.	(15.5, 593,† 792.5, 848, 1046.5)
	liq.	− 92	$+O_2$	(101, 136, 592, 976)
COS	gas	92	+KOH; &	(84, 641,* 944, 976)
$C_2H_5SO_4^-$	aq.	904	$NaC_2H_5SO_4$	
$C_2H_6SO_4$	aq.	906	$C_2H_4 + H_2SO_4$ &	(74)
CN^-	aq.	− 146	KCN	
C_2N_2	liq.	− 274	→gas	(265)
	gas	− 296	$+O_2$	(147, 976)
	aq.	− 268	−28	(149, 496)
NCN_3	c	− 396	dissoc.	(304)
$NCN_{3(polymer.)}$	c	− 346	dissoc.	(304)

Formula	State	Q, kj	Method	Lit.
Carbon.—(*Continued*)				
CNO^-	aq.	145	NaCNO	
$C_3N_3O_3^{---}$	aq.	558	$Na_3C_3N_3O_3$	
CN_2H^-	aq.	− 95	$NaHCN_2$	
HCN	gas	− 126	$+O_2$; &	(53, 976)
	liq.	− 99.1	→gas;* &	(53, 233,* 499,* 791*)
	c^{-15}	− 91.6	liq.*	(791,* 817*)
	aq.	− 100	25	(53, 255)
CH_3NH_2	gas	31	$+O_2$	(626)
	aq.	81	51	(221, 741, 976)
$CH_3NH_3^+$	aq.	136	CH_3NH_3Cl	
CN_2H_2	c	− 36	$+O_2$	(626)
	liq.	− 45	→c*	(826†)
	aq.	− 52	-15^{15}_{1000}	(626)
NH_4CN	c	4	-18.2_{400}; &	(70, 543*)
	aq.	− 14	N	(70)
$(CH_3)_2NH$	gas	32	$+O_2$	(627, 741, 976)
	aq.	93	61.3_{780}	(221)
$C_2H_5NH_2$	gas	52	$+O_2$	(102, 627, 976)
	aq.	106	54.0	(221)
$(CH_3)_3N$	gas	26	$+O_2$	(102, 627, 741, 976)
	aq.	80	54.2	(221)
$(CN_2H_2)_2$	c	− 10.9	$+O_2$	(626)
	aq.	− 35.0	-24.1^{15}	(626)
HCNO	aq.	153	$+NH_4OH$	(70)
NH_4HCO_3	c	850	-28^{15}_{1200}; &	(50, 361)
	400	822.7	dil.	(976)
	200	823.1	dil.	
	100	824	N; &	(150)
	40	824.4	dil.	
$2NH_3.CO_2$	c	650.0	−25; &	(236,* 237,* 621,* 679, 685,* 834)
	aq.	626	N; &	(50, 679, 976)
$CO(NH_2)_2$	c	328.5	$+O_2$	(171, 331, 598, 950)
	aq.	314.5	−14.0; &	(171, 789.5°, 976)
NH_4CNO	c	308	$CO(NH_2)_2$; &	(1026)
	aq.	282	N	(1026)
$(NH_4)_2CO_3$	aq.	935	ions	
NH_4CHO_2	c	560	-12.0^{10}_{140}	(55, 73, 976)
	400	548	N, analogy	
$NH_4CH_3CO_2$	c	625	1.0^{24}_{200}	(55)
	400	625.9	N	(55)
	200	625.8	dil.	(325,† 976)
	100	625.4	dil.	
	50	624.9	dil.	
	25	624.0	dil.	
	10	622.3	dil.	
	5	620.1	dil.	
	2	618.6	dil.	
$NH_4HC_2O_4$	400	948.7	N	(73)
$CH_3NH_2.H_2CO_3$	aq.	820	N	(741)
$(NH_4)_2C_2O_4$	c	1118	−33	(73)
	400	1085	N	(73)
$(NH_4)_2C_2O_4.H_2O$	c	1419	−48	(73)
$(CH_3NH_2)_2.H_2CO_3$	aq.	930	N	(741)
$HC_3N_3O_3^{--}$	aq.	608	$Na_2HC_3N_3O_3$	
$H_2C_3N_3O_3^-$	aq.	650	$NaH_2C_3N_3O_3$	
$C_3N_3H_3O_3$	c	693	$+O_2$	(626)
	aq.	679	−13	(626)
$C_3N_3H_3O_3.2H_2O$	c	1281	−28.8	(626)
$NH_4H_2C_3N_3O_3$	aq.	781	N	(626)
$NH_4H_2C_3N_3O_3.H_2O$	c	1114	-46.9^{11}_{400}; &	(626)
$(NH_4)_2HC_3N_3O_3$	aq.	869	N	(626)
$(NH_4)_3C_3N_3O_3$	aq.	955	N	(626)
$NH_4HC_4H_4O_6$	400	1376	N	(56)
$(NH_4)_2C_4H_4O_6$	400	1507	N	(56)
	200	1507.7	dil.	(976)
	100	1508.0	dil.	
	50	1509.6	dil.	
	30	1511.0	dil.	
	21	1511.9	dil.	

Formula	State	Q, kj	Method	Lit.
Carbon.—(*Continued*)				
CNCl	gas	− 153	$Hg(CN)_2 + Cl_2$; &	(70)
	liq.	− 118	→gas	(70)
$C_3N_3Cl_3$	c	29	$+O_2$; &	(626)
$CH_3NH_2.HCl$	aq.	30_0	N	(721)
$C_3N_5ClH_4$	c	105	$+O_2$	(626)
CNI	c	− 177	KCN + I	(70)
	aq.	− 188	-11.6^{20}_{100}	(70)
CNS^-	aq.	− 76	KCNS	
HCNS	aq.	− 77	N	(55)
NH_4CNS	c	81	-23.7^{12}	(55)
	aq.	57	N	(55)
$HSbOC_4H_4O_6$	c	1461	+HF; &	(468)
$HSbOC_4H_4O_6.4C_4H_6O_6$	aq.	6467	$HSbOC_4H_4O_6 + C_4H_6O_6$	(468)
Silicon				
Si	c	0	Def.	
	amorp.	− 4	Si + O_2; &	(998, 1029)
SiO_2	gls.	83_0	Si + O_2	(706, 825, 1029)
$SiO_{2(\alpha\ quartz)}$	c	842.6	+HF	(740, 839, 1042)
$SiO_{2(\beta\ quartz)}$	■		Tr.; $0.6^{573}_{(\alpha quartz)}$	(1042)
$SiO_{2(\alpha\ cristobalite\ 1600)}$	c	839.5	+HF	(1042)
$SiO_{2(\beta\ cristobalite\ 1600)}$	■		Tr.; $0.6_{(\alpha\ crist.)}$	(1042)
$SiO_{2(\alpha\ cristobalite\ 1000)}$	c	838.9	+HF	(1042)
$SiO_{2(\beta\ cristobalite\ 1000)}$	c		Tr.; $0.2_{(\alpha\ crist.)}$	(1042)
$SiO_{2(\beta\ tridymite)}$ (*see also* p. 106)	c		Tr.; $0.1_{(\alpha\ tridymite)}$	(1042)
$SiO_2.H_2O$	coll.	826	+HF	(740)
$SiO_{2(56.6H_2O)}$	coll.	827	+HF	(740)
$SiO_{2(\infty\ H_2O)}$	coll.	825		
SiH_4	gas	5_0	dissoc.; &	(768, 1029)
H_4SiO_4	coll.	1397	$=SiO_{2\ \infty}$	
SiF_4	gas	1512	HF + SiF_4	(464, 465, 1000)
$SiF_6^=$	aq.	2289	Na_2SiF_6	
H_2SiF_6	200	2281	HF + SiO_2	(464, 465, 1000)
	4	2264	dil.	(1000)
$H_2SiF_6.4H_2O$	liq.	3303	33	(1000)
$SiCl_4$	gas	597	→liq.	(768)
	liq.	624	Si + Cl_2; &	(84, 768, 998)
$SiBr_4$	liq.	383	83^9_{2000}	(84)
SiI_4	c	116	86^9_{12000}	(84)
$SiS_{2(white)}$	c	134	39^{10}	(897)
$SiS_{2(yellow)}$	c	121	45^{10}	(897)
Si_3N_4	c	634	$SiO_2 + N_2 + O_2$*	(681)
$(NH_4)_2SiF_6$	c	2592	-35^7_{1200}	(1002)
	aq.	2557	$SiF_4 + NH_4F$; &	(1002)
SiC	c	6	O_2; &	(706)
$(C_2H_5O)_4SiO_4$	liq.	1309	90	(768)
Titanium[a]				
Ti	c	0	Def.	
TiO_2	c	910	Ti + O_2; &	(709, 1038)
	amorp.	896	Ti + O_2; &	(709, 1038)
$TiO_{2(III)\ (rutile)}$	c			
$TiO_{2(II)}$	■		Tr.; $1.3^{540}_{(III)}$	(609)
$TiO_{2(I)}$	c		Tr.; $3.1^{778}_{(II)}$	(609)
$TiO_{2(III)\ (anatase)}$	n			
$TiO_{2(II)}$	■		Tr.; $1.1^{600}_{(III)}$	(609)
$TiO_{2(I)}$	c		Tr.; $1.6^{785}_{(II)}$	(609)
$TiO_2.xH_2O$	coll.	88_0 + xH_2O	analogy	(709)
$TiF_6^=$	aq.	2327	Na_2TiF_6	
H_2TiF_6	aq.	2331	$TiO_2.xH_2O$ + HF	(976)

[a] $TiCl_3$ (brown) heat of solution 48.6, $TiCl_3$ (blue) heat of solution 45.8 (207).

Formula	State	Q, kj	Method	Lit.
Titanium.—(*Continued*)				
$TiCl_4$	liq.	768	242^{18}_{2000}	(207, 976)
H_2TiCl_6	aq.	1350	$TiCl_4$ + HCl aq.	(976)
Zirconium[a]				
Zr	c	0	Def.	
ZrO_2	gls.	748	Zr + O_2	(1040)
$Zr(OH)_4$	ppt.		N	(270)
$ZrOCl_2$	aq.			
$ZrOCl_2.2H_2O$	c		67	(269)
$ZrOCl_2.3\frac{1}{2}H_2O$	c		38	(269)
$ZrOCl_2.6H_2O$	c		3	(269)
$ZrOCl_2.8H_2O$	c		−13	(269)
$ZrOBr_2.3\frac{1}{2}H_2O$	c		37.7	(271)
$ZrOBr_2.8H_2O$	c		−8.4	(271)
$ZrO(NO_3)_2.2H_2O$	c		9.1	(273)
$ZrO(NO_3)_2.3H_2O$(?)	c		−2.1	(273)
$ZrO(NO_3)_2.3\frac{1}{2}H_2O$	c		−8.0	(273)
$ZrO(NO_3)_2.6H_2O$	c		−24.7	(273)
$ZrOSO_4.4H_2O$	c		43	(272)
$ZrOSO_4.SO_3$	c		137.2	(272)
$ZrOSO_4.H_2SO_4$	c		86	(272)
ZrC	c	146	ZrO + C*	(828*)
Tin				
$Sn_{(rhom.)}$	c		Tr.; $0.04^{161}_{(tetrag.)}$	(1045)
$Sn_{(tetrag.)}$	c	0	Def.	
$Sn_{(gray)}$	c	− 2.2	Tr.; $2.2^{0}_{(tetrag.)}$	(242, 282, 698)
Sn^{++}	aq.	10	$SnCl_2$	
Sn^{++++}	aq.	− 4	$SnCl_4$	
SnO	c	292	$+O_2$	(322, 708)
$SnO_{2(fused)}$	c	578	Sn + O_2; &	(308)
$SnO_2^=$	aq.	456	Na_2SnO_3	
$SnO_{2(II)\ (cassiterite)}$	c		Tr.; $1.3^{540}_{(III)}$	(609)
$SnO_{2(I)\ (cassiterite)}$	c		Tr.; $1.9^{430}_{(II)}$	(609)
$Sn(OH)_2$	coll.	570.7	$SnCl_2$ + NaOH	(976)
$H_4SnO_{4(fresh)}$	coll.	1357	$SnCl_4$ + KOH	(976, 1014)
$SnF_6^=$	aq.	1963	N = H_2SiF_6	
H_2SnF_6	aq.	1967	$SnCl_4$ + HF	(976)
$SnCl_2$	c	339.6	1.5^{18}_{300}	(84, 976)
$SnCl_{2(2HCl)}$	aq.	341.1	+Zn; &	(759, 976)
$SnCl_2.2H_2O$	c	936	-22.1^{18}_{200}	(84, 185, 976)
$SnCl_4$	liq.	533	125.2^{20}_{250}	(84, 976)
	gas	495	→liq.	(15.5, 1072)
$SnCl_{4(2HCl)}$	aq.	658.2	$SnCl_2$ + HClO; &	(69, 976)
$SnCl_6^=$	aq.	988	K_2SnCl_6	
H_2SnCl_6	aq.	989	= $SnCl_4$ + HCl	
$SnBr_2$	c	257	−7	(84, 185)
$SnBr_2$	aq.	251	+KCl	(84)
$SnBr_4$	liq.	386	$\rightarrow c^{31}$	(84, 433,† 983)
	c	398	69	(84, 984)
	aq.	467	$SnCl_4$ + KBr	(84, 511)
SnI_2	c	150	analogy	(185)
	aq.	138	+KCl	(84)
$SnCl_2.2\frac{1}{2}NH_3$	c	614	$+58.6_{HCl}$	(185*)
$SnCl_2.4NH_3$	c	678	dissoc.*	(185*)
$SnCl_2.9NH_3$	c	1067	dissoc.*	(185*)
$SnBr_2.NH_3$	c	384	dissoc.*	(185*)
$SnBr_2.2NH_3$	c	487	+HCl; &	(185*)
$SnBr_2.3NH_3$	c	585	+HCl; &	(185*)
$SnBr_2.5NH_3$	c	759	dissoc.*	(185*)
$SnBr_2.9NH_3$	c	1069	dissoc.*	(185*)
$SnI_2.NH_3$	c	263	dissoc.*	(185*)
$SnI_2.2NH_3$	c	365	+HCl; &	(185*)
$SnI_2.3NH_3$	c	460	+HCl; &	(185*)
$SnI_2.5NH_3$	c	637	dissoc.*	(185*)
$SnI_2.9NH_3$	c	953	dissoc.*	(185*)
SnS	c	100	$+H_2$*	(552*)

[a] Includes 0–2 % Hafnium.

Formula	State	Q, kj	Method	Lit.
Lead[a]				
Pb	c	0	Def.	
$Pb_{(stick)}$	c	− 0.3	+Hg*	(439*)
Pb^{++}	aq.	2	$Pb(NO_3)_2$	
$PbO_{(red)}$	c	219.6	$+H_2$;* &	(931,* 993*°, 1088*)
PbO_2	c	262	$+SO_2$; &	(274, 305,* 709)
Pb_2O	c	214.5	$+H_2C_2O_4$	(512)
Pb_3O_4	c	729	dissoc.*	(620, 851*)
$Pb(OH)_2$	ppt.	576	$Pb(NO_3)_2$ + NaOH	(58, 976)
PbF_2	c	667.1	$Pb(NO_3)_2$ + HF	(464, 465)
$PbCl_2$	c	358.5	Pb + Cl_2*; &	(229, 230, 248,* 439,* 594,* 780)
	aq.	331.1	−27.4	(55, 245,† 976)
$PbCl_2.PbO$	c	597	76_{HCl}	(11)
$PbCl_2.2PbO$	c	820	167_{HCl}	(11)
$PbCl_2.3PbO$	c	1037	265_{HCl}	(11)
$PbBr_2$	c	277.3	$K_2C_4H_4O_6$; &	(229, 976)
	aq.	235.3	-42.0^{18}_{2500}	(976)
$PbBr_2.PbO$	c	501	104_{HBr}	(11)
$PbBr_2.2PbO$	c	717	209_{HBr}	(11)
$PbBr_2.3PbO$	c	935	316_{HBr}	(11)
PbI_2	c	175.1	Pb + I; &	(229, 230, 439,* 967)
$PbI_2.HI.5H_2O$	c	1678	-16^{11}_{200}	(130)
PbS	ppt.	93	$Pb(NO_3)_2$ + Na_2S	(60, 553, 907,* 976)
$PbSO_{4(I)}$	c		Tr.; $17.0^{866}_{(II)}$	(1091)
$PbSO_{4(II)}$	c	898	$Pb(NO_3)_2$ + H_2SO_4; &	(976)
PbS_2O_3	c	616	$Na_2S_2O_3$ + $NaC_2H_3O_2$	(369)
PbS_2O_6	aq.	1150	Pb^{++} + $S_2O_6^=$	
$PbS_2O_6.4H_2O$	c	2330	-35.7^{18}_{400}	(976)
PbS_3O_6	c	1119	−20.9	(369)
	aq.	1097	ions	
PbSe	ppt.	99	$Pb(C_2H_3O_2)_2$ + H_2Se	(350)
	c	52	+Br aq.	(350)
$PbSeO_4$	c	627	Na_2SeO_4 + $Pb(NO_3)_2$	(696)
PbTe	c	23 (?)	+Br	(351)
PbN_6	c	− 421	dissoc.	(1113)
$Pb(NO_3)_2$	c	453.2	-31.8^{18}_{400}	(54, 959, 976)
	400	421.3	dil.	
	200	423.5	$PbCl_2$ + HNO_3; &	(976)
	100	426.7	dil.	
	40	431.8	dil.	
$Pb(NO_3)_2.PbO$	c	707	$Pb(NO_3)_2$ + NaOH	(976)
$PbCl_2.NH_3$	c	456	dissoc.*	(184*)
$PbCl_2.1\frac{1}{2}NH_3$	c	506	dissoc.*	(184*)
$PbCl_2.2NH_3$	c	552	dissoc.*	(184*, 335)
$PbCl_2.3\frac{1}{2}NH_3$	c	659	dissoc.*	(184*)
$PbCl_2.8NH_3$	c	1040	dissoc.*	(184*)
$2PbCl_2.NH_4Cl$	c	1032.7	$PbCl_2$ + NH_4Cl	(244)
$PbBr_2.NH_3$	c	388	dissoc.*	(184*)
$PbBr_2.2NH_3$	c	482	dissoc.*	(184*, 335*)
$PbBr_2.3NH_3$	c	567	dissoc.*	(184*)
$PbBr_2.5\frac{1}{2}NH_3$	c	777	dissoc.*	(184*)
$PbBr_2.8NH_3$	c	977	dissoc.*	(184*)
$PbI_2.\frac{1}{2}NH_3$	c	228	dissoc.*	(184*)
$PbI_2.NH_3$	c	279	dissoc.*	(184*)
$PbI_2.2NH_3$	c	372	dissoc.*	(184*)
$PbI_2.5NH_3$	c	631	dissoc.*	(184*, 335*)
$PbI_2.8NH_3$	c	866	dissoc.*	(184*)
$PbSO_4.(NH_4)_2SO_4$	c	2068.0	$PbSO_4$ + $(NH_4)_2SO_4$	(30)
$PbHPO_3$	c	970	Na_2HPO_3 + $Pb(NO_3)_2$	(8)
$PbCO_3$	c	707	$+HNO_3$	(58, 668)
	ppt.	703	$+HNO_3$	(668, 976)

[a] Alloys with Sn (655).

Formula	State	Q, kj	Method	Lit.
Lead.—(*Continued*)				
$PbCO_3.PbO$	c	928	$+HNO_3$	(668, 1005)
$PbCO_3.2PbO$	c	1151	dissoc.*	(1005)
PbC_2O_4	c	863	$Pb(NO_3)_2 + K_2C_2O_4$	(58, 668)
$Pb(CHO_2)_2$	c	859	-29^{10}	(55)
	aq.	830	$Pb(OH)_2 + HCHO_2$	(55)
$Pb(CH_3CO_2)_2$	c	979.3	5.9^{11}_{220}	(55)
	aq.	985.4	$PbO + HC_2H_3O_2$; &	(55, 976)
$Pb(CH_3CO_2)_2.3H_2O$	c	1867	-23^{11}_{100}	(55)
$PbO.Pb(CH_3CO_2)_2$	c	1226	$Pb(C_2H_3O_2)_2 + NaOH$; &	(976)
$Pb(CN)_2.2PbO.H_2O$	c	523	$154^{19}_{HNO_3}$	(555)
$Pb(CNS)_2$	c	− 120	$Pb(C_2H_4O_2)_2 + KCNS$	(555)
Thorium				
Th	c	0	Def.	
Th^{++++} (?)	aq.	998	$ThCl_4$	
ThO_2	c	1385	$Th + O_2$	(268, 1028)
ThH_4	c	− 179	dissoc.	(684)
$Th(OH)_4$(dried ppt.)	ppt.	1407	$+HCl$	(268)
$Th_3(OH)_4$(condensed)	ppt.	1360	$+HCl$	(268)
$ThCl_4$	c	1402	237^{15}; &	(268, 1028)
	aq.	1641	$Th + HCl$	(268)
$ThCl_4.2H_2O$	c	2041	171.9	(268)
$ThCl_4.4H_2O$	c	2675	109.8	(268)
$ThCl_4.7H_2O$	c	3582	61	(268)
$ThCl_4.8H_2O$	c	3882	47.9	(268)
$ThOCl_2$	c	1410	117.8	(268)
$ThCl_3OH.H_2O$	c	1669	199	(268)
$ThBr_4$	c	1176	293.7	(268)
	aq.	1470	ions	(268)
$ThBr_4.7H_2O$	c	3379	94.4	(268)
$ThBr_4.10H_2O$	c	4291	41.2	(268)
$ThBr_4.12H_2O$	c	4895	10	(268)
$ThOBr_2$	c	1334	117.0	(268)
ThI_4	aq.	1221	ions	(268)
$ThOI_2$	c	1212	90.1	(268)
$ThOI_2.\frac{1}{2}H_2O$	c	1781	42	(268)
$ThI_3.OH.10H_2O$	c	3812	35.3	(268)
$Th(SO_4)_2$	aq.	2770	ions	
$Th(SO_4)_2.4H_2O$	c	3893	21	(591)
$Th(SO_4)_2.8H_2O$	c	5090	−31	(591)
$ThCl_4.2NH_4Cl$	c	2069	166.6	(268)
$ThCl_4.2NH_4Cl.10H_2O$	c	5114	−16	(268)
$ThCl_4.4NH_3$	c	1920	258_{HCl}	(268)
$ThCl_4.6NH_{3(\alpha)}$	c	2142	306.0_{HCl}	(268)
$[Th.6NH_3]Cl_{4(\beta)}$	c	2297	148_{HCl}	(268)
$ThCl_4.7NH_{3(\alpha)}$	c	2194	346.3_{HCl}	(268)
$[Th.6NH_3]Cl_4.NH_{3(\beta)}$	c	2435	142.9_{HCl}	(268)
$ThCl_4.12NH_{3(\alpha)}$	c	2672	585_{HCl}	(268)
$[Th.6NH_3]Cl_4.6NH_{3(\beta)}$	c	2864	392_{HCl}	(268)
$ThCl_4.18NH_{3(\alpha)}$	c	3127	896_{HCl}	(268)
$[Th.6NH_3]Cl_4.12NH_{3(\beta)}$	c	3304	719_{HCl}	(268)
$Th(CO_3)_2$	(?)	3579	$ThSO_4.4H_2O + K_2CO_3$	(591)
Indium[a]				
In	c	0	Def.	
In^{+++}	aq.	113	$InCl_3$	
In_2O_3	c	100	$+O_2$	(315)
InCl	c	187	$+KBr + Cl_2$	(1099*)
$InCl_2$	c	363	$+KBr + Cl_2$	(1099*)
$InCl_3$	c	538	$In + Cl_2$	(1099*)
	aq.	608	$71_{HCl(22)}$	(1098*)
$InBr_3$	c	407	$65_{HCl(22)}$	(1098*)
	aq.	472	ions	
InI_3	c	136	$44_{HCl(22)}$	(1098*)
	aq.	280	ions	
$InCl_3.NH_3$	c	675	$64_{HCl(22)}$	(1098*)
$InCl_3.2NH_3$	c	806	$66_{HCl(22)}$	(1098*)
$InCl_3.3NH_3$	c	934	$70_{HCl(22)}$	(1098*)
$InCl_3.5NH_3$	c	1125	$144_{HCl(22)}$	(1098*)

[a] Indium amalgams, heat of dilution (873).

Formula	State	Q, kj	Method	Lit.
Indium.—(*Continued*)				
$InCl_3.7NH_3$	c	1288	dissoc.*	(1098*)
$InCl_3.15NH_3$	c	2246	dissoc.*	(1098*)
$InBr_3.3NH_3$	c	797	$72_{HCl(22)}$	(1098*)
$InBr_3.5NH_3$	c	1004	$129_{HCl(22)}$	(1098*)
$InBr_3.7NH_3$	c	1170	$228_{HCl(22)}$	(1098*)
$InBr_3.15NH_3$	c	1810	dissoc.*	(1098*)
$InI_3.NH_3$	c	367	dissoc.*	(1098*)
$InI_3.2NH_3$	c	486	$59_{HCl(22)}$	(1098*)
$InI_3.5NH_3$	c	826	$116_{HCl(22)}$	(1098*)
$InI_3.7NH_3$	c	1012	$194_{HCl(22)}$	(1098*)
$InI_3.9NH_3$	c	1176	dissoc.*	(1098*)
$InI_3.13NH_3$	c	1491	dissoc.*	(1098*)
$InI_3.21NH_3$	c	2101	dissoc.*	(1098*)
Thallium[a]				
$Tl_{(I)}$	c		Tr; $0.21^{226}_{(II)}$	(1045)
$Tl_{(II)}$	c	0	Def.	
Tl^+	aq.	− 4	TlOH	
Tl^{+++}	aq.	− 123	$TlBr_3$	
Tl_2O	c	176.4	-12.9^{18}_{570}	(26, 976)
TlOH	c	238.0	-13.2^{18}_{235}	(422, 976)
	aq.	224.8	$+HCl$	(976)
$Tl(OH)_3$	c	607.1	$+HBr$	(976)
TlF	aq.	323.5	N	(422, 793)
$HTlF_2$	800	637.4	$HF + TlF$	(793)
TlCl	c	203.8	$Tl + PbCl_2$*; &	(439,* 976)
	aq.	161	-42^{18}_{4500}	
$TlCl_3$	c	337.9	$+35.3_{300}$	(972)
	aq.	373.2	ions	(976)
$TlCl_3.4H_2O$	c	1527.1	-8.9_{300}	(972)
TlBr	c	171.8	$Tl_2SO_4 + HBr$; &	(976)
$TlBr_3$	aq.	236.1	$+SO_2$	(976)
$TlBr_3.4H_2O$	c	1390.2	-9.4_{480}	(972)
$TlBr_2Cl$	aq.	282	$TlBr_3 + TlCl_3$	(972)
$TlBr_2Cl.4H_2O$	c	1438.9	-12.1_{300}	(976)
TlI	c	126.0	$Tl_2SO_4 + HI$	(976)
Tl_2S	c	92	$Na_2S + TlNO_3$	(976)
Tl_2SO_4	c	911.4	-34.6^{18}_{1600}	(976)
	800	876.8	N; &	(976)
	200	878.2	dil.	(422, 976)
Tl_2Se	c	50	$+Br$	(351)
	ppt.	50	$TlC_2H_3O_2 + H_2Se$	(351)
Tl_2Te	c	30	$+Br$	(351)
TlN_3	c	− 229	dissoc.	(1113)
$TlNO_{3(I)}$	c		Tr; $3.2^{145}_{(II)}$	(234*)
$TlNO_{3(II)}$	c		Tr; $1.0^{75}_{(III)}$	(234*)
$TlNO_{3(III)}$	c	246.1	-41.7^{18}_{300}	(976)
	aq.	204.4	N	(976)
$TlCl.3NH_3$	c	431	dissoc.*	(196)
$TlBr.3NH_3$	c	398	dissoc.*	(196)
$TlI.3NH_3$	c	353	dissoc.*	(196)
$TlOC_2H_5$	c	230	−2.2	(423.5)
	C_2H_5OH	232	$Tl + C_2H_5OH$	(423.5)
$TlC_2H_3O_2$	aq.	488	N; &	(422)
TlONC	c	− 109	dissoc.	(1113)
Zinc[b]				
Zn	c	0	Def	
	gas	−131	[illegible]→c*	(329,* 460,* 516,* 517,* 536,* 657,* 693,* 792,* 876,* 1069*)
Zn^{++}	aq.	153	$ZnSO_4$	(444)
$ZnO_{(fused)}$	c	353	$Zn + O_2$; &	(16, 95, 307, 308, 315, 323, 359, 390, 490, 659, 666, 711, 730.5, 1067)
$ZnO_{(low\ temp.)}$	c	349	$105.6_{H_2SO_4(200)}$; [illegible]	(390, 658, 666)

[a] $Tl_2SO_4.10NH_3$ (343). Thallium amalgams (860, 870, 873).

[b] For heat of dissociation of the ammines of various zinc salts, *v.* (335, 339, 341). Alloys with Sn (655).

Formula	State	Q, kj	Method	Lit.
Zinc.—(*Continued*)				
$Zn(OH)_2$ (?)	c	663	$79_{H_2SO_4(200)}$	(390, 717)
$Zn(OH)_2$	amorp.	642.3	$ZnSO_4$ + KOH; &	(390, 976)
$Zn(OH)_2.H_2O_{(ordin.\ ppt.)}$	amorp.	928.5	$+H_2SO_4$	(390)
$ZnO_2.2H_2O$	c	1056	$62.2_{H_2SO_4(200)}$	(390)
$ZnO.\frac{1}{3}H_2O$	c	454	$64.8_{H_2SO_4(200)}$	(390)
$Zn_3O_3.2H_2O$	∎	1543	$201.4_{H_2SO_4(200)}$	(390)
ZnF_2	aq.	804.8	$ZnCl_2$ + AgF	(793)
$ZnCl_2$	c	416.6	65.8^{18}_{600}	(32, 811, 976)
	400	482.4	Zn + HCl; &	(188, 197, 858, 872, 919, 933, 1087,* 1099)
	200	480.8	dil.	(976)
	100	477.3	dil.	
	50	471.0	dil.	
	20	461.9	dil.	
	10	456.4	dil.	
	5	448.6	dil.	
$ZnCl_2.3ZnO.5H_2O$	c	2952	257_{HCl}	(11)
$ZnCl_2.4ZnO.11H_2O$	c	5040	321_{HCl}	(11)
$ZnCl_2.5ZnO.8H_2O$	c	4536	400_{HCl}	(11)
$ZnCl_2.8ZnO.10H_2O$	c	6188	621_{HCl}	(11)
$ZnBr_2$	c	326	62.9	(11, 976)
	400	389	$ZnSO_4$ + $BaBr_2$; &	(511, 976)
$ZnBr_2.4ZnO.13H_2O$	c	5517	326_{HBr}	(11)
ZnI_2	c	208	49; & *	(1035, 1093*)
	650	257	Zn + I_2	(1036)
$ZnI_2.5ZnO.11H_2O$	c	3935	484_{HI}	(966)
ZnS	c	192	$+Na_2O_2$	(715)
	ppt.	173	$Zn(C_2H_3O_2)_2$ + H_2S; &	(60, 976)
$ZnSO_2$	aq.	616	Zn + SO_2	(78)
$ZnSO_4$	c	960.5	77.6^{17}_{400}	(458, 694,* 976)
	400	1038.1	+NaOH; &	(976)
	200	1038.1	dil.	(390, 976)
	100	1038.0	dil.	(976)
	50	1037.8	dil.	
	20	1036.4	dil.	
$ZnSO_4.H_2O$	c	1282.4	41.8^{18}_{400}	(458, 976*)
$ZnSO_4.6H_2O$	c	2759	-3.5^{18}_{400}	(287, 355, 429,* 749,*° 880,* 976)
$ZnSO_4.7H_2O$	c	3059.2	-17.9^{18}_{400}	(429, 458, 694, 976)
ZnS_2O_4	aq.	818	ions	
ZnS_2O_6	400	1301	ions	
$ZnS_2O_6.6H_2O$	c	3028.0	−9.4	(976)
ZnSe	c	140	$+Br_2$	(350)
	ppt.	131	$Zn(C_2H_3O_2)_2$ + Na_2Se	(350)
ZnTe	c	139	+Br	(351)
ZnN_6	c	− 213	dissoc.	(1113)
$Zn(NO_3)_2$	400	569.6	ions	
	200	569.7	dil.	(976)
	100	569.9	dil.	
	50	570.2	dil.	
	20	570.0	dil.	
	15	569.0	dil.	
	10	565.2	dil.	
	3	556	extrap.	
$Zn(NO_3)_2.3H_2O$	c	1450	→liq.	(1105)
$Zn(NO_3)_2.6H_2O$	c	2311.1	-24.5^{18}_{400}	(732, 976)
$ZnCl_2.NH_3$	c	566	dissoc.*	(193*)
$ZnCl_2.2NH_3$	c	693.2	+HCl; &	(193,* 539)
$ZnCl_2.4NH_3$	c	884	+HCl; &	(193,* 539)
$ZnCl_2.6NH_3$	c	1068	+HCl; &	(193,* 222,* 339,* 539*)
$ZnCl_2.10NH_3$	c	1370	dissoc.*	(193,* 334*)
$ZnCl_2.5NH_3.H_2O$	c	1231	196_{HCl}	(11)
$ZnCl_2.2NH_3.\frac{1}{2}H_2O$	c	757	$57.5_{HCl(100)}$	(11)
$ZnCl_2.ZnO.8NH_4Cl$	c	3254	40_{HCl}	(11)
$3ZnCl_2.6NH_4Cl.H_2O$	c	3478	27	(11)
$3ZnCl_2.ZnO.10NH_4Cl$	c	3822	68_{HCl}	(11)
$6ZnCl_2.ZnO.12NH_3$	c	5639	400_{HCl}	(11)
$ZnBr_2.NH_3$	c	514	dissoc.*	(193*)
$ZnBr_2.2NH_3$	c	644	dissoc.*	(193,* 339*)
$ZnBr_2.4NH_3$	c	849	dissoc.*; &	(11, 193, 332,* 334*)
$ZnBr_2.6NH_3$	c	1032	dissoc.*	(193*)
$ZnBr_2.6NH_3.H_2O$	c	1319	153_{HBr}	(11)
$ZnI_2.NH_3$	c	345	dissoc.*	(193*)
$ZnI_2.2NH_3$	c	471	dissoc.*	(193*)
$ZnI_2.4NH_3$	c	695	93.6_{HI}; &	(193,* 966)
$ZnI_2.6NH_3$	c	878	dissoc.*	(193,* 339)
$Zn(NH_4)_2(SO_4)_2.2H_2O$	c	2735	dissoc.*	(262*)
$Zn(NH_4)_2(SO_4)_2.6H_2O$	c	3962	−55	(334, 458)
$ZnCO_3$	ppt.	809	$ZnSO_4$ + Na_2CO_3	(58)
$ZnC_2O_4.2H_2O$	c	1562	$ZnSO_4$ + $K_2C_2O_4$	(56)
$Zn(C_2H_5)_2$	liq.	31	326_{HCl}; &	(467)
$Zn(CHO_2)_2$	c	961	17^{15}_{500}	(55)
	250	978	$ZnSO_4$ + $NaCHO_2$	(55)
$Zn(CHO_2)_2.2H_2O$	c	1560	-10^{13}_{500}	(55)
$Zn(C_2H_3O_2)_2$	c	1093	41^{22}_{720}	(55)
	400	1134.1	$Ba(C_2H_3O_2)_2$ + $ZnSO_4$; &	(55, 976)
	200	1130.4	dil.	
	100	1126.0	dil.	
	50	1120.9	dil.	
$Zn(C_2H_3O_2)_2.H_2O$	c	1392	29^{23}_{800}	(55)
$Zn(C_2H_3O_2)_2.2H_2O$	c	1689	18^{10}_{500}	(55)
$Zn(CN)_2$	c	− 68	14_{HCl}	(152, 555)
$3Zn(CN)_2.ZnO$	c	167	95_{HCl}	(152, 555)
$ZnSiO_3$	c	1199	$358_{HF(20\%)}$	(740)
Zn_2SiO_4	gls.	1450	$416_{HF(20\%)}$	(740)
	c	1487	$379_{HF(20\%)}$	(740)
$ZnSn_{2.0}$	c	− 25	+Br	(511)
$ZnSn_{0.6}$	c	− 54	+Br	(511)
$ZnSn_{0.21}$	c	− 17	+Br	(511)
$ZnSn_{0.1}$	c	− 21	+Br	(511)
Cadmium[a]				
$Cd_{(\alpha)}$	c	0	Def.	
$Cd_{(\beta)}$	c	− 0.23	α*	(443*)
	g	− 112	→α*	(228,* 329,* 370,* 657,* 792,* 881,* 1069*)
Cd^{++}	aq.	73	$Cd(NO_3)_2$	(285)
CdO	c	273	Cd + O; &	(315, 715, 730.5)
$Cd(OH)_{2(ordin.\ ppt.)}$	ppt.	559	$CdSO_4$ + KOH; &	(976)
CdF_2	1200	721.9	$CdCl_2$ + AgF	(793)
$CdCl_2$	c	389.2	13.0^{18}_{400}	(197, 283,† 552,* 810,° 858, 869, 871, 976)
	400	402.1	dil.	(976)
	200	401.3	dil.	
	100	400.6	dil.	
	50	400.1	dil.	
	20	397.6	dil.	
	10	390.7	dil.	(283, 976)
$CdCl_2.H_2O$	c	685.5	$+2.6^{18}_{400}$; &	(810°)
$CdCl_2.2\frac{1}{2}H_2O$	c	1129.9	-12.3^{18}_{400}; &	(283,°* 969*)
$CdCl_2.4H_2O$	c	1938	dissoc.*	(1020*)
$CdCl_2.2HCl.7H_2O$	c	2744	-10^{11}_{15}	(100)
$CdCl_2.CdO.H_2O$	c	988	56^{15}_{HCl}	(966)
$CdBr_2$	c	317.2	1.8^{18}_{400}	(976)
	400	319	Cd + Br; &	(511, 754, 976)
$CdBr_2.4H_2O$	c	1494.1	-30.5^{18}_{600}	(976)
$CdBr_2.CdO.H_2O$	c	911	60.0^{16}_{HBr}	(966)
CdI_2	c	202.5	Cd + I_2; &	(284,* 969*)
	400	198.5	-4.0^{19}_{400}	(284, 291,* 976)

[a] $Cd(ClO_3)_2.6NH_3$, $Cd(ClO_3)_2.4NH_3$, $Cd(IO_3)_2.4NH_3$; heat of dissoc. (341*). Alloys with Pb, Sn (655).

Formula	State	Q, kj	Method	Lit.
Cadmium.—(*Continued*)				
$CdI_2.CdO.H_2O$	c	756	108.2^{12}_{HI}	(966)
CdS	c	142	$+Na_2O_2$	(715)
	ppt.	145	$CdSO_4 + Na_2S$	(976)
$CdSO_4$	c	912.0	44.7^{18}_{400}; &	(2900)
	400	956.72	dil.	(290,c† 525)
	200	955.9	$+BaCl_2$; &	(976)
	100	955.24	dil.	(525†)
	50	954.40	dil.	
	30.6	952.20	dil.	
	20.6	950.81	dil.	
	15.6	948.86	dil.	
	13.6	945.37	dil.	
$CdSO_4.2.67H_2O$	c	1709.2	10.6^{18}_{400}	(525, 544,* 941†)
CdS_2O_6	aq.	1221	$BaS_2O_6 + CdSO_4$	(976)
CdSe	ppt.	90 (?)	$CdSO_4 + Na_2Se$	(350)
	c	70	+Br	(350)
CdTe	c	66	+Br	(351)
CdN_6	c	− 445	dissoc.	(1113)
$Cd(NO_3)_2$	400	489.9	$CdSO_4 + Ba(NO_3)_2$	(976)
$Cd(NO_3)_2.H_2O$	c	758.6	17.5^{18}_{400}	(976)
$Cd(NO_3)_2.4H_2O$	c	1655.7	-21.1^{19}_{400}	(976)
$CdCl_2.NH_3$	c	510	dissoc.*	(1081*)
$CdCl_2.2NH_3$	c	630	35.8^{16}_{HCl}	(966, 1081*)
$CdCl_2.4NH_3$	c	806	dissoc.*	(1081*)
$CdCl_2.4NH_4Cl$	c	1651	-57.5^{15}	(966)
$CdCl_2.6NH_3$	c	991	dissoc.*	(334,* 1081*)
$CdCl_2.10NH_3$	c	1292	dissoc.*	(1081*)
$2CdCl_2.2NH_4Cl.H_2O$	c	1729	-44.9^{16}	(966, 1081)
$CdBr_2.NH_3$	c	438	dissoc.*	(1081*)
$CdBr_2.2NH_3$	c	552	32.5^{15}_{HBr}	(966, 1081)
$CdBr_2.6NH_3$	c	917	dissoc.*	(332*)
$CdBr_2.12NH_3$	c	1383	dissoc.*	(1081*)
$2CdBr_2.2NH_4Br.H_2O$	c	1485	-60^{16}	(966)
$CdI_2.2NH_3$	c	410	50^{15}_{HI}; &	(966*)
$CdI_2.6NH_3$	c	779	dissoc.*	(332*)
$2CdI_2.2NH_4I.H_2O$	c	1126	-66.0^{15}	(966)
$CdSO_4.4NH_3$	c	1307	dissoc.*	(335*)
$CdSO_4.6NH_3$	c	1497	dissoc.*	(335,* 536*)
CdSb	c	11	$+Br_2$	(186)
Cd_3Sb_2	c	17	$+Br_2$	(186)
$CdCO_3$	ppt.	748	$CdSO_4 + Na_2CO_3$; &	(976)
$Cd(CN)_2$	c	− 154	$35^{20}_{H_2SO_4}$; &	(555)
$Cd(ONC)_2$	c	− 151	dissoc.	(1113)
$Cd(CN)_2.CdO.5H_2O$	c	1955	$53^{18}_{H_2SO_4}$; &	(555)
$CdZn_{(0.36)}$	c	− 15	$+Br_2$	(511)
$CdZn_{(1.28)}$	c	− 29	$+Br_2$	(511)
$CdZn_{(4.61)}$	c	− 25	$+Br_2$	(511)
Mercury[a]				
Hg	liq.	0	Def.	(460.5, 584.5, 599.5, 792.5)
	gas	− 60.2	→liq.	
Hg^{++}	aq.	− 174	$Hg(NO_3)_2$	
Hg_2^{++}	aq.	− 168	$Hg_2(NO_3)_2$	
$HgO_{(red)}$	c	91	$+Hg_2$; &	(242, 1008)
$HgO_{(yellow)}$	ppt.	87	$HgCl_2 + KOH$; &	(108, 976)
Hg_2O	c	90	$Hg_2Cl_2 + KOH$; &	(976, 1008)
$HgCl_2$	c	223.6	-13.9^{18}_{300}	(53, 811, 976)
	aq.	210	+KI; &	(69, 976)
Hg_2Cl_2	ppt.	263.7	+KI; &	(439,* 637,* 976, 1008, 1065*)
$HgCl_2.HgO$	c	317	59^{9}_{HCl}	(11, 12)
$HgCl_2.2HgO$	c	409	131^{11}_{HCl}	(11, 12)
$HgCl_2.3HgO$	c	496	210^{9}_{HCl}	(11, 12)
$HgCl_2.4HgO$	c	583	289_{HCl}	(11, 12)

[a] Amalgams, *cf.* other metals. Amalgams with Sn, Cd, Bi, Pb, *v.* (655). In (873), Tl (870, 873).

Formula	State	Q, kj	Method	Lit.
Mercury.—(*Continued*)				
H_2HgCl_4	aq.	548	$HCl + HgCl_2$	(754, 976, 1008)
$HgBr_2$	c	174	$Hg + Br_2$; &	(754, 976, 1008)
	aq.	156	-14^{12}_{KBr}	(106)
Hg_2Br_2	ppt.	206	+Br; &	(754, 976, 1008)
$HgBr_2.HgO$	c	270	148.5^{9}_{HBr}	(11, 12)
$HgBr_2.2HgO$	c	360	291^{9}_{HBr}	(11, 12)
$HgBr_2.3HgO$	c	453	430.5^{9}_{HBr}	(11, 12)
$HgBr_2.4HgO$ (?)	c	524	572^{9}_{HBr}	(11, 12)
H_2HgBr_4	1500	424	$HgBr_2 + HBr$	(107, 1011)
$HgI_{2(red)}$	c	106	$Hg + I + KI$; &	(1008)
$HgI_{2(yellow)}$	c	93	Tr.; $13^{18}_{(red)}$	(107, 204)
$Hg_2I_{2(yellow)}$	c	120.8	+KI; &	(1008)
$Hg_2I_{2(yellow\text{-}green)}$	ppt.	120.2	Tr.; $0.6^{18}_{(yellow)}$; &	(1008)
H_2HgI_4	aq.	357.1	$HgI_2 + HI$	(786, 1008)
$HgS_{(red)}$	c	45.6	$HgS_{(black)}$	(1008)
$HgS_{(red)}$	amorp.	45.4	$HgS_{(black)}$	(1008)
$HgS_{(black)}$	amorp.	44	$HgCl_2 + H_2S$	(60)
$HgSO_4$	c	680	+HCl; &	(1008)
	$4H_2SO_4$-(100)	701	$HgSO_4 + H_2SO_4$	(1008)
Hg_2SO_4	c	718.1	+KI; &	(292, 505, 1008)
$3HgO.SO_3$	c	899	$38_{H_2SO_4(200)}$	(1008)
$HgSO_4.2H_2SO_4$	100	1566.6	$HgSO_4 + H_2SO_4$	(1008)
	200	1569.4	$HgSO_4 + H_2SO_4$	(1008)
HgSe	c	17	+Br	(350, 786*)
	ppt.	22	$HgCl_2 + Na_2Se$	(350, 786*)
$Hg_2(N_3)_2$	c	− 408	dissoc.	(176, 1113)
$Hg(NO_3)_2$	aq.	243	+NaOH	(976)
$Hg_2(NO_3)_2$	aq.	249.0	$Hg_2(NO_3)_2 + KCl$	(976)
$Hg_2(NO_3)_2$	HNO_3(100)	245.6	$Hg_2(NO_3)_2.2H_2O + HNO_3$; &	(976, 1008)
$Hg_2(NO_3)_2.2H_2O$	c	870	$-52^{HNO_3}_{KI}$; &	(976, 1008)
$(Hg(NO_3)_2)_2.H_2O$	c	782	-5.9_{4HNO_3}; &	(1008)
$Hg(NO_3)_2.2HgO.H_2O$	c	1029	16_{HNO_3}; &	(1008)
$(Hg_2N)_2O$	c	− 322	632_{24KCN}	(435)
	aq.	− 307	+KCN	(435)
$(Hg_2N)_2O.H_2O$	c	− 23	619_{24KCN}	(435)
$(Hg_2N)_2O.4H_2O$	c	870	587_{24KCN}	(435)
$(Hg_2N)_2O.5H_2O$	c	1582	577_{24KCN}	(435)
$(NHg_2Cl)_2.H_2O$	c	230	$N_2Hg_4O.4H_2O + HCl$	(435)
$(NHg_2Cl.H_2O)_2$	c	531	514_{24KCN}	(435)
$HgCl_2.2NH_3$	c	527	$43_{HCl(g)}$; &	(1081*)
$HgCl_2.8NH_3$	c	932	dissoc.*	(1081*)
$HgCl_2.9\frac{1}{2}NH_3$	c	1046	dissoc.*	(1081*)
$Hg_2Cl_2.2NH_3$	c	475	dissoc.*	(222, 537)
$NHg_2Cl.NH_4Cl$	c	592	228_{24KCN}	(435)
$NHg_2Cl.3NH_4Cl$	c	1212	204_{24KCN}	(435)
$(NHg_2Cl)_2.NH_3$	c	47	508_{24KCN}	(435)
$NHg_2Cl.NH_3$	c	66	dissoc.*	(435)
$(NHg_2Cl)_2.HgCl_2$	c	201	679_{24KCN}	(435)
$HgBr_2.2NH_3$	c	398	$85_{KCN(16)}$	(1081*)
$HgBr_2.8NH_3$	c	817	dissoc.*	(1081*)
$(NH_4)_2.HgBr_4$	1500	670	$NH_4Br + HgBr_2$	(1012)
NHg_2Br	c	− 62	253_{24KCN}	(435)
$(NHg_2Br)_2.HgBr_2$	c	91	+KCN	(435)
$(NHg_2Br)_4.HgBr_2$	c	− 15	1097_{21KCN}	(435)
$NHg_2Br.NH_4Br$	c	238	210_{24KCN}	(435)
$NHg_2Br.3NH_4Br$	c	789	+KCN	(435)
$HgI_2.\frac{1}{2}NH_3$	c	181	dissoc.*	(1081*)
$HgI_2.2NH_3$	c	301	$90_{KCN(16)}$	(1081*)
$HgI_2.8NH_3$	c	610	dissoc.*	(1081*)
HgC_2O_4	c	670	$29.4^{9}_{HCl(100)}$	(114)
$Hg(C_2H_3O_2)_2$	c	829	-17^{18}_{440}	(114)
	aq.	812	HCl; &	(114)

Formula	State	Q, kj	Method	Lit.
Mercury.—(*Continued*)				
$HgH_2(C_2H_3O_2)_4$	aq.	1807	$HC_2H_3O_2 + Hg(C_2H_3O_2)_2$	(114)
$Hg_2(C_2H_3O_2)_2$	c	851	+KI; &	(1008)
$Hg(C_2H_3O_2)_2.HgO$	c	916	$Hg(C_2H_3O_2)_2$ +KOH	(1008)
$Hg(CN)_2$	c	− 260	−13	(53, 976)
	aq.	− 272	$HgCl_2$ + KCN	(108, 976)
$Hg(CN)_4^=$	aq.	− 515	$Na_2Hg(CN)_4$	(172, 1097, 1113)
$Hg(C_2N_2O_2)$	c	− 270	dissoc.	
$Hg(CN)_2.HgO$	c	− 164	57_{HCl}	(555)
$3Hg(CN)_2.HgO$	c	− 653	0.8_{HCl}	(555)
$Hg(CN)_2.NH_4CN$	400	− 256	mix.	(1009)
$Hg(CN)_2.2NH_4CN$	600	− 248	mix.	(1009)
$Hg(CN)_2.HgCl_2$	c	− 38	-23^{14}	(106)
	aq.	− 61	mix.	(106)
$Hg(CN)_2.NH_4Cl$	500	26	mix.	(1009)
$Hg(CN)_2.NH_4Cl.\frac{1}{2}H_2O$	c	272	−31.6	(1009)
$Hg(CN)_2.NH_4Br$	500	− 18	mix.	(1009)
$Hg(CN)_2.NH_4Br.H_2O$	c	312	−43.9	(1009)
$Hg(CN)_2.NH_4I$	500	− 75	mix.	(1009)
$Hg(CN)_2.NH_4I.\frac{1}{2}H_2O$	c	48	−51.3	(1009)
$Hg(CNS)_2$	c	− 211	$HgCl_2$ + KCNS	(555)
$HgSn_2$	liq.		dil.*	(513, 873, 960)
$Hg_{\infty}Pb$	liq.	− 11.3	Hg + Pb*	(637)
$Hg_{100}Pb$	liq.	− 10.5	dil.*	(862,* 960)
$Hg_{250}Pb$	liq.	− 11.0	dil.*	(862)
$Hg_{1000}Pb$	liq.	− 11	dil.*	(862)
$HgPb_3$	c	− 0.2	Hg + Pb*	(241,* 439,* 505*)
$Hg_{22}Zn$	liq.	− 9.4	Zn + Hg*	(863*)
$Hg_{66}Zn$	liq.	− 9.7	dil.	(862*)
$HgBr_2.ZnBr_2$	4400	556	mix.	(1012)
$2HgBr_2.ZnBr_2$	8400	713	mix.	(1012)
$HgBr_2.2ZnBr_2$	4800	957	mix.	(1012)
$Hg(CN)_2.ZnCl_2$	1000	− 60	mix.	(1009)
$Hg(CN)_2.ZnCl_2.7H_2O$	c	1999	-56.0^{15}	(1009)
$Hg(CN)_2.ZnBr_2$	1000	− 150	mix.	(1009)
$Hg(CN)_2.ZnBr_2.8H_2O$	c	2226	-87^{16}	(1009)
$Hg_{66}Cd$	liq.	2.1	Cd + Hg*	(863,* 960)
HgCd (10% amalgam)	c	− 23.7	Cd + Hg*	(443,* 534*)
$HgBr_2.CdBr_2$	4400	485	mix.	(1012)
$2HgBr_2.CdBr_2$	8400	640	mix.	(1012)
$HgBr_2.2CdBr_2$	4800	809	mix.	(1012)
$Hg(CN)_2.CdCl_2$	600	131	mix.	(1009)
$Hg(CN)_2.CdCl_2.2H_2O$	c	742	-39^{15}	(1009)
$Hg(CN)_2.CdBr_2$	600	− 49	mix.	(1009)
$2Hg(CN)_2.CdBr_2$	1000	− 223	mix.	(1009)
$Hg(CN)_2.CdBr_2.3H_2O$	c	933	-52^{14}	(1009)
$2Hg(CN)_2.CdI_2$	100	− 339	mix.	(1009)
$2Hg(CN)_2.CdI_2.8H_2O$	c	2043	-93^{15}	(1009)
Copper.[a]				
Cu	c	0	Def.	
Cu^{++}	400	− 69	$CuCl_2$	
CuO	c	146	H_2SO_4; &	(16, 416, 557, 713, 902, 976, 993,* 1055*)
Cu_2O	c	167	dissoc.;* &	(16, 322, 874,* 976, 993*)
$Cu(OH)_{2(blue)}$	ppt.	438.2	$+H_2SO_4$; &	(416, 976)
$Cu(OH)_{2(green)}$	ppt.	439.3	$60.5^{18}_{HNO_3}$	(416, 902)
$3CuO.H_2O_{(brown)}$	ppt.	730	$66.0^{18}_{HNO_3}$	(416, 902)
CuF_2	400	585	$CuCl_2$ + AgF	(793)
CuCl	c	136	Cu_2O + HCl; &	(215,* 326,* 552,* 759,* 780, 976)
	HCl	109	-27.0^{25}_{HCl}	(91, 759, 780)
$CuCl_2$	c	215.2	46.5^{18}_{600}	(900, 976)
	800	262.0	dil.	
	400	261.6	dil.	

[a] $CuTl_2(SO_4)_2.6H_2O$, heat of dissociation (261). Heat of dissociation of ammines of $Cu(IO_3)_2$; CuS_4O_6; $Cu(CNS)_2$; $Cu(ClO_3)_2$; $Cu(NO_3)_2$; CuS_2O_6; $Cu(ClO_4)_2$; CuC_2O_4; $Cu(HCO_2)_2$; $Cu(C_2H_3O_2)_2$ (340). Alloys with Cd, Ag (913).

Formula	State	Q, kj	Method	Lit.
Copper.—(*Continued*)				
$CuCl_2$.—(*Continued*)	200	259.5	CuO + HCl; &	(51, 91, 759,† 879, 976)
	100	257.6	dil.	(51, 849,† 976)
	50	254.6	dil.	
	30	250.9	dil.	
	20	247.5	dil.	
	10	240.6	dil.	
$CuCl_2.2H_2O$	c	816.2	15.5^{18}_{200}	(312,† 900, 976)
$Cu(ClO_3)_2$	400	93	$Ba(ClO_3)_2$ + $CuSO_4$	(976)
$CuCl_2.3CuO$	c	672	230_{HCl}	(103)
$HCuCl_2$	550	439	$CuCl_2$ + HCl	(759)
$CuCl_2.3CuO.4H_2O_{(atacamite)}$	c	1909	138_{HCl}	(103)
CuBr	c	103	N; &	(215,* 976)
$CuBr_2$	c	134	34.5^{20}_{400}	(901,° 976)
	400	168	$CuSO_4$ + $BaBr_2$; &	(511, 876, 976)
$CuBr_2.4H_2O$	c	1319	−6	(901)
$CuBr_2.3Cu(OH)_2$	c	1532	136_{HBr}	(901)
CuI	c	66	$CuSO_4$ + KI; &	(91, 215,* 976)
CuI_2	c	13	$+NH_3$ analogy	
	aq.	38	ions	
CuS	c	48.6	Cu + S	(976, 1027)
$Cu_2S_{(I)}$	c		Tr.; $3.8^{103}_{(II)}$	(45.5)
$Cu_2S_{(II)}$	c	79.4	Cu + S	(4,* 60, 830,* 1027)
$CuSO_4$	c	748.0	66.5^{18}_{800}; &	(360.5, 458, 810,° 910, 976, 1058*)
	800	814.6	dil.	
	200	814.4	$CuCl_2$ + H_2SO_4; &	(51, 976)
	100	814.1	dil.	(976)
	60	813.9	dil.	(976)
$CuSO_4.H_2O$	c	1061.6	39.1^{18}_{800}	(320,* 458, 910, 920, 976)
$CuSO_4.3H_2O$	c	1281	$+H_2O$;* &	(781*)
$CuSO_4.5H_2O$	c	2257.1	-11.7^{18}_{800}; &	(320, 360.5, 429,* 458, 630,* 810, 909, 976)
Cu_2SO_4	c	726	88	(844)
CuS_2O_6	aq.	1071	ions	
$CuS_2O_6.5H_2O$	c	2523	-20.5^{18}_{400}	(976)
$CuSO_4.CuO$	c	92o	$+CuO$*; &	(850*)
$CuSO_4.3CuO.4H_2O$	c	1581	$201_{H_2SO_4}$	(902)
CuSe	ppt.	2o	$Cu(C_2H_3O_2)_2$ + H_2Se	(350)
$Cu_2Se_{(I)}$	c		Tr.; $4.7^{110}_{(II)}$	(45.5)
$Cu_2Se_{(II)}$	c	31	+Br	(350)
$CuSeO_4$	400	538	+KOH	(696)
$CuSeO_4.5H_2O$	c	1980	−11.1	(696)
Cu_2Te	c	17	+Br	(351)
CuN_3	c	− 238	dissoc.	(1113)
$Cu(NO_3)_2$	c	303	43.8^{8}_{280}	(482)
	200	346.5	$Ba(NO_3)_2$ + $CuSO_4$; &	(416, 976)
	100	346.7	dil.	(51, 432, 976)
	50	347.2	dil.	
	20	347.4	dil.	
	15	346.6	dil.	
	12	345.4	dil.	
	10	343.5	dil.	
$Cu(NO_3)_2.3H_2O$	c	1216	-10^{18}	(902)
$Cu(NO_3)_2.6H_2O$	c	2108.4	-44.8^{18}_{400}	(902, 976)
$Cu(NO_3)_2.3CuO.3H_2O$	c	1711	142_{HNO_3}	(902)
$[Cu.4NH_3]^{++}$	400	329	$CuSO_4$ + NH_3; &	(224)
$[Cu.6NH_3]^{++}$	500	501	$CuSO_4$ + NH_3; &	(224)

Formula	State	Q, kj	Method	Lit.
Copper.—(*Continued*)				
$[Cu.8NH_3]^{++}$	600	667	$CuSO_4$ + NH_3; &	(224)
$[Cu.12NH_3]^{++}$	900	995	$CuSO_4$ + NH_3; &	(224)
$CuO.28NH_3$	3000	245.2	$Cu(OH)_2$ + NH_3; &	(224)
	1500	245.1	dil.	
	500	244.7	dil.	
$CuCl.NH_3$	c	251.1	dissoc.*	(196,* 650*)
$CuCl_2.2NH_3$	c	493	33.3_{HCl}; &	(224, 1080*)
$CuCl_2.2NH_4Cl$	c	827	20^{15}_{550}	(224)
$CuCl_2.2NH_3.\frac{1}{4}H_2O$	c	561	11_{12NH_3}	(224)
$CuCl_2.5NH_3$	c	793	dissoc.*	(1080*)
$CuCl_2.2NH_4Cl.2H_2O$	c	1393	−26	(224)
$CuCl.3NH_3$	c	428	dissoc.*	(196,* 650*)
$CuCl_2.3\frac{1}{2}NH_3$	c	632	-23_{NH_3}	(224, 335*)
$CuCl_2.4NH_3$	aq.	660	mix.	(224)
$CuCl_2.4NH_3.2H_2O$	c	1293	-52_{2NH_3}	(224)
$CuCl_2.5NH_3.\frac{1}{2}H_2O$	c	929	−39	(224)
$CuCl_2.5NH_3.1\frac{1}{2}H_2O$	c	1217	−40	(224)
$CuCl_2.6NH_3$	aq.	832	mix.	(224)
$CuCl_2.10NH_3$	c	182	dissoc.*	(1080*)
$2CuCl.3NH_3$	c	601	dissoc.*	(196,* 650)
$CuBr.NH_3$	c	210	dissoc.*	(196*)
$CuBr_2.2NH_3$	c	402	$20_{HCl(20)}$	(1080*)
$CuBr.3NH_3$	c	389	dissoc.*	(196,* 650)
$CuBr_2.3\frac{1}{2}NH_3$	c	550	dissoc.*	(1080*)
$CuBr_2.5NH_3$	c	716	dissoc.*	(1080*)
$CuBr_2.10NH_3$	c	1108	dissoc.*	(1080*)
$2CuBr.3NH_3$	c	521	dissoc.*	(196,* 650)
$CuI.\frac{1}{2}NH_3$	c	122	dissoc.*	(196*)
$CuI.NH_3$	c	176	dissoc.*	(196*)
$CuI.2NH_3$	c	268	dissoc.*	(196,* 650)
$CuI.3NH_3$	c	358	dissoc.*	(196,* 650)
$CuI_2.2NH_3$	c	277	$+NH_3$*	(1080*)
$CuI_2.3\frac{1}{4}NH_3$	c	420	$+Br^-$	(1080)
$CuI_2.5NH_3$	c	591	dissoc.*	(1080*)
$CuI_2.10NH_3$	c	963	dissoc.*	(1080*)
$CuSO_4.NH_3$	c	891	92_{27NH_3}	(224)
$CuSO_4.2NH_3$	c	1018	46_{2NH_3}	(224)
$CuSO_4.(NH_4)_2SO_4$	c	1925	41.2^{14}	(224)
$CuSO_4.(NH_4)_2SO_4.2H_2O$	c	2493	dissoc.*	(261*)
$CuSO_4.(NH_4)_2SO_4.6H_2O$	c	3728	−44.4	(355, 458)
$CuSO_4.4NH_3$	c	1235	-7.6_{24NH_3}; &	(224, 335*)
	aq.	1215	mix.	(224)
$CuSO_4.4NH_3.1.5H_2O$	c	1682	30_{NH_3}	(224)
$CuSO_4.5NH_3$	c	1343	dissoc.*	(335*)
$CuSO_4.6NH_3$ (?)	c	1346	$+NH_3$	(224)
$CuSO_4.6NH_3$	aq.	1386	mix.	(224)
$CuSO_4.8NH_3$	aq.	1551	mix.	(224)
$CuSO_4.12NH_3$	aq.	1879	mix.	(224)
Cu_3Sb	c	10	$+Br_2$	(186)
$CuCO_3$	ppt.	592	$CuSO_4$ + K_2CO_3	(58)
$Cu(CHO_2)_2$	c	751	2.2^{15}_{600}	(55)
	aq.	753	N	(55)
$Cu(CHO_2)_2.4H_2O$	c	1930	-33^{10}_{500}	(55)
$Cu(C_2H_3O_2)_2$	c	898	10^{16}_{320}	(55)
	aq.	908	$+Ba(OH)_2$	(976)
$Cu(C_2H_3O_2)_2.H_2O$	c	1193	0.7^{18}_{400}	(55, 976)
$CuCl_2.CO.2H_2O$	c	1000(?)	CuCl + HCl + CO	(495)
$Cu(C_2H_5SO_4)_2$	aq.	1785	$Ba(C_2H_5SO_4)_2$ + $CuSO_4$	(976)
$CuCN$	c	− 117	$Hg(CN)_2$ + CuI	(1007)
$CuONC$	c	− 99	dissoc.	(1113)
Cu_3Sn	c	33	+Br	(181, 511)
Cu_2Zn_3	c	67	+Br	(28, 181, 432, 511)
Cu_2Cd_3	c	12	+Br	(181, 186)
Silver[a]				
Ag	c	0	Def.	
$Ag_{(ppt\ by\ Cu)}$	ppt.	− 4(?)	+Hg	(141)

[a] For heat of solution of various silver salts of organic acids, *v.* (600, 889); organic ammines of silver (561); alloys with Cd (913). Ammines with $AgBrO_3$, $AgClO_3$, $AgNO_2$, $AgMnO_4$ (337).

Formula	State	Q, kj	Method	Lit.
Silver.—(*Continued*)				
Ag^+	∞	− 104	$AgNO_3$	
Ag_2O	c	29.1	dissoc.;* &	(11, 144, 146, 581,* 641.1,* 713, 976)
Ag_2O_2	c	22.6	$+HClO_4$; &	(1094)
AgF	c	203.8	18.0^{10}	(481)
$AgF_{(red)}$	amorp.	203.8	18^{16}	(481)
	400	221.8	+HCl; &	(465, 793)
$AgF.H_2O$	c	504.3	3.6^{10}	(481)
$AgF.2H_2O$	c	800.4	-6^{10}	(481)
$AgF.4H_2O$	c	1387.1	-20.6^{13}	(464, 481)
Ag_2F	c	210.5	11.5	(465)
$AgF.HF$	aq.	546.6	mix.	(464)
$AgCl$	ppt.	126.6	+Hg;* &	(110, 230, 367, 439,* 494,* 594, 635,* 760,* 1065*)
	c	128	$+PbCl_2$*	(239,* 552,* 572,* 594,* 857, 1065*)
	aq.	68	conductivity*	(695*)
Ag_2Cl (?)	c	130	+KCN	(470)
$AgClO_3$	c	7	−31.5	(371)
	aq.	− 24	ions; &	(38*)
$AgClO_4$	c	51.2	9.1	(253)
	aq.	60.3	+HCl; &	(1094)
$AgBr$	c	99.8	Ag + Br; &	(58, 573,† 584,* 594,* 976, 1036)
$AgI_{(I)}$			Tr.; $5.32^{147}_{(II)}$	(45.2, 660, 1084)
$AgI_{(II)}$	ppt.	62.5	Ag + I; &	(230, 367, 439,* 442,* 570,* 584, 594,* 967,† 968, 1036)
$3AgI.HI.7H_2O$	c	2256	−9	(100)
$Ag_2S_{(I)}$	c		Tr.; $4.0^{175}_{(II)}$	(451, 553, 786*)
$Ag_2S_{(II)}$	c	21	$AgNO_3$ + H_2S; &	(62, 362,* 976)
Ag_2SO_4	c	695	+KOH; &	(146, 665,* 976)
	aq.	676	+KOH; &	(976)
$Ag_2S_2O_3$ (?)	c	(?)		(369)
$Ag(S_2O_3)_2^{+++}$	aq.	1159	$Na_3Ag(S_2O_3)_2$	(369)
$Ag_2S_2O_6$	aq.	938	ions	
$Ag_2S_2O_6.2H_2O$	c	967	-43.4^{18}_{400}	(976)
$AgSe$	ppt.	− 4.0	$AgC_2H_3O_2$ + H_2Se	(350, 786*)
$Ag_2Se_{(I)}$	c		Tr.; $6.9^{133}_{(II)}$	(45.5)
$Ag_2Se_{(II)}$	c	4.0	$+Br_2$	(350)
Ag_2SeO_4	c	401	$AgNO_3$ + K_2SeO_4	(696)
AgN_3	c	− 277	dissoc.	(1113)
$AgNO_2$	c	53	−37	(55, 71)
	aq.	18	ions	(55, 71)
$AgNO_{3(I)}$	c		Tr.; $2.4^{160}_{(II)}$	(234*)
$AgNO_{3(II)}$	c	126	-22.9^{18}_{400}; &	(795, 976)
$AgNO_3$	400	103.2	+HCl; &	(58, 124, 546,* 734, 783,* 976)
$Ag_2N_2O_2$	c	− 122	N	(169)
$Ag(NH_3)_2^+$	aq.	104	$AgClO_4.2NH_3$	
$AgNO_3.NH_3$	c	251	dissoc.*	(337)
$AgNO_3.2NH_3$	c	358	−37.9	(154, 253, 337,* 554)
	aq.	320	ions; &	(154, 253, 554, 561, 626)
$AgNO_3.3NH_3$	c	444	−43.7	(253, 337,* 554, 560)
	aq.	401	$AgNO_3$ + NH_3; &	(253)
$Ag(NH_3)_3OH$	aq.	829	Ag_2O + NH_3	(154)
$AgCl.NH_3$	c	224	dissoc.*	(195)
$AgCl.1\frac{1}{2}NH_3$	c	271	dissoc.*; &	(195, 539)

Formula	State	Q, kj	Method	Lit.
Silver.—(*Continued*)				
$AgCl.3NH_3$	c	405	dissoc.*; &	(195, 539)
$AgClO_4.2NH_3$	c	323	−44.8	(253)
	2000	277	+HCl	(253)
$AgClO_4.3NH_3$	c	406	−46.8	(253)
	3000	359	+HCl	(253)
$AgBr.NH_3$	c	190	dissoc.*	(195*)
$AgBr.1\frac{1}{2}NH_3$	c	234	dissoc.*	(560*)
$AgBr.3NH_3$	c	357	dissoc.*	(560*)
$AgI.\frac{1}{2}NH_3$	c	110	dissoc.*; &	(195,* 560)
$AgI.NH_3$	c	151	dissoc.*; &	(195*)
$AgI.1\frac{1}{2}NH_3$	c	189	dissoc.*; &	(195*)
$AgI.2NH_3$	c	226	dissoc.*; &	(195*)
$AgI.3NH_3$	c	301	dissoc.*; &	(195*)
Ag_2C_2	c	− 351	C_2H_2 + $AgNO_3.2NH_3$	(153)
Ag_2CO_3	c	506	$AgNO_3$ + K_2CO_3; &	(58)
	ppt.	490	$AgNO_3$ + K_2CO_3; &	(58)
$Ag_2C_2O_4$	c	668	$K_2C_2O_4$ + $AgNO_3$	(56)
$Ag_2C_4H_4O_6$	c	1047	$AgNO_3$ + $K_2C_4H_4O_6$	(56)
$AgC_2H_3O_2$	c	406	−18.4	(55, 457, 600, 889†)
	aq.	388	N	(55)
$Ag_2C_2.AgCl$	c	− 210	49	(153)
$2Ag_2C_2.AgCl$	c	547	97	(153)
$Ag_2C_2.AgI$	c	− 215	53^{18}_{HCl}	(153)
$Ag_2C_2.2AgI$	c	− 282	58.0^{18}_{HCl}	(153)
$Ag_2C_2.Ag_2SO_4$	c	357	C_2H_2 + Ag_2SO_4	(153)
$2Ag_2C_2.Ag_2SO_4$	c	57	164_{HCl}	(153)
$AgCN$	c	− 140	$AgNO_3$ + KCN; &	(113, 976, 1011)
$Ag(CN)^-_2$	aq.	− 245	$KAg(CN)_2$	
$Ag(CN)^-_3$	aq.	− 403	$K_2Ag(CN)_3$	(976)
$Ag_2(CN)_2$	c	− 209	80.6_{HCl}; &	(626)
$AgONC$	c	− 181	dissoc.	(1113
$AgCNO$	c	99	$AgNO_3$ + KCNO	(626)
$Ag_2C_2.AgNO_3$	aq.	− 205	Ag_2C_2 + $AgNO_3$; &	(153)
$Ag_2C_2N_2O_2$	c	374	$Na_2C_2N_2O_2$ + NH_3 + $AgNO_3$	(626)
$AgCN.NH_3$	c	33	dissoc.*	(560*)
$AgC_2H_5NH^+_2$	aq.	148	Ag^+ + $C_2H_5NH^-_2$	(561)
$AgH_2C_2N_2O_2$	c	600.6	$AgNO_3$ + $NaH_2C_2N_2O_2$	(626)
$AgCl.CH_3NH_2$	c	209	dissoc.*	(550*)
$AgBr.CH_3NH_2$	c	182	dissoc.	(550*)
$AgI.CH_3NH_2$	c	151	dissoc.	(550*)
$AgCNS$	c	− 88	$AgNO_3$ + HCNS	(555)
	aq.	− 177	−89*	(583)
$AgSbOC_4H_4O_6$	c	1402	$AgNO_3$ + $KSbOC_4H_4O_6$	(468)
Ag_2Hg_4	c	3.0	+Hg	(142, 649)
$AgI.PbI_2$	c		Tr.; − 10.7	(45.2)
$AgI.CuI$	c		Tr.; − 12.3	(45.2)
$AgI.2CuI$	c		Tr.; − 36.3	(45.2)
Gold[a]				
$Au_{(\beta)}$	c	0	Def.	
$Au_{(\alpha)}$ (from $AuCl_3$ + SO_2) (?)		15(?)	$AuCl_3$ + H_2SO_3	(976)
Au_2O_3	c	− 54	Na_2O_2	(713)
$Au(OH)_3$	ppt.	418	+HCl aq.	(976)
$AuCl$	c	43	+HCl; &	(338,* 679,* 787,* 976)
$AuCl_2$ (?)	c	79	+HCl	(796)

[a] $AgCuCl_4$, heat of dissociation (780.5).

Formula	State	Q, kj	Method	Lit.
Gold.—(*Continued*)				
$AuCl_3$	c	113	$+18.6^{18}_{900}$	(679,* 787, 798,* 976)
	aq.	132	+HBr	
$AuCl^-_4$	aq.	316	$N = \frac{1}{2}H_2PtCl_6$	
$AuCl_3.2H_2O$	c	711	-7.1^{18}_{600}	(976)
$AuHCl_4$	aq.	316	$AuCl_3$ aq. + HCl	(976)
$AuHCl_4.3H_2O$	c	1189	−14.9	(976)
$AuHCl_4.4H_2O$	c	1485	-24.4^{18}_{400}	(976)
$AuBr$	c	19	+HBr; &	(698, 976)
$AuBr_2$ (?)	c	34	+HBr	(796)
$AuBr_3$	c	56	-15.7^{18}_{2000}	(338,* 698,* 976)
	aq.	41	+HBr; &	(976)
$AuBr^-_4$	aq.	192	$N = \frac{1}{2}H_2PtCl_6$	
$AuHBr_4$	aq.	192	$+SO_2$; &	(976)
$AuHBr_4.5H_2O$	c	1872	-47.7^{18}_{1000}	(976)
AuI	c	4	$+H_2SO_3$; &	(976)
$AuCl.NH_3$	c	192	$122_{KCN(70)}$	(1078)
$AuCl.2NH_3$	c	297	dissoc.*	(338*)
$AuCl.6NH_3$	c	600	$97_{KCN(70)}$	(1078*)
$AuBr.NH_3$	c	155	$103_{KCN(70)}$	(1078*)
$AuBr.2NH_3$	c	256	$93_{KCN(70)}$	(1078*)
$AuBr.3NH_3$	c	337	dissoc.*	(1078*)
$AuBr.4NH_3$	c	416	dissoc.*	(1078*)
$AuBr.6NH_3$	c	575	dissoc.*	(1078*)
$AuI.NH_3$	c	105	$84_{KCN(70)}$	(1078*)
$AuI.2NH_3$	c	190	dissoc.*	(1078*)
$AuI.3NH_3$	c	282	dissoc.*	(1078*)
$AuI.6NH_3$	c	521	dissoc.*	(1078*)
$AuI.8NH_3$	c	614	dissoc.*	(1078*)
$Au(CN)^-_2$	aq.	− 226	$KAu(CN)_2$	
$AuSn$	Hg	50	$Sn + Au_{Hg}$	(960)
$AuZn$	Hg	60	$Zn + Au_{Hg}$	(960)
$AuCd$	Hg	40	$Cd + Au_{Hg}$	(960)
$AuHg_{100}$	liq.	− 8	Au + Hg	(960)
Osmium				
Os	c	0	Def.	
OsO_4	c	391	$+O_2$	(1031)
	liq.[40]	376.8	$\rightarrow c^{40}$	(1031)
	gas	334	$\rightarrow c$*	(1031*)
Iridium				
Ir	c	0	Def.	
IrO_2	c	21	dissoc.*	(1064*)
$IrCl_2$	c	86	dissoc.*	(1059*)
	c	170	dissoc.*	(1059*)
$IrCl_3$	c	253	dissoc.*	(1059*)
Platinum				
Pt	c	0	Def.	
PtH (?)	c	80	$Pt + H_2$	(115, 356)
$Pt(OH)_2$	ppt.	367	$+HCHO_2$	(976)
$PtCl$	c	70	dissoc.*	(1060*)
$PtCl_2$	c	150	dissoc.*	(1060*)
$PtCl_3$	c	210	dissoc.*	(1060*)
$PtCl_4$	c	262	$104^{11}_{HCl(300)}$	(815, 1060*)
	aq.	343	+HCl	(815)
$PtCl^-_4$	aq.	511	K_2PtCl_4	
$PtCl_4.5H_2O$	c	1782	-7.7_{400}	(815)
$PtCl^-_6$	aq.	693	K_2PtCl_6	
H_2PtCl_4	aq.	510	$N = H_2PtCl_6$	
H_2PtCl_6	aq.	693	+NaOH; &	(815, 976)
$HPtCl_5.2H_2O$	c	1040	60.0_{HCl}	(815)
$H_2PtCl_6.6H_2O$	c	2392	18.2_{500}	(815)
$PtBr_4$	c	168	41_{1000}	(815)
	aq.	209	+Co; &	(815)
$PtBr^-_4$	aq.	376	K_2PtBr_4	
$PtBr^-_6$	aq.	483	K_2PtBr_6	
H_2PtBr_6	aq.	483	$N = H_2PtCl_6$	
$H_2PtBr_6.9H_2O$	c	3071	−12.0	(815)
PtI_4	c	70	31_{NaI}	(816)
PtI^-_6	aq.	218	Na_2PtI_6	

Formula	State	Q, kj	Method	Lit.
Platinum.—(*Continued*)				
$Pt(NH_3)_4^=$	aq.	419	$Pt(NH_3)_4Cl_2$	
$Pt(NH_3)_4(OH)_2$	aq.	875	N	(976)
$(NH_4)_2PtCl_4$	c	812	−35.2	(976)
	aq.	777	ions	
$PtCl_2.2NH_3$	c	500	$PtCl_2 + NH_3$; &	(540)
$PtCl_2.4NH_3$	c	766	analogy	
	aq.	749	$= PtCl_2.4NH_3.H_2O$	
$PtCl_2.4NH_3.H_2O$	c	1071	−36.7	(976)
$PtCl_2.5NH_3$	c	855	dissoc.*	(343*)
$PtI_2.2NH_3$	c	Q		
$PtI_2.4NH_3$	c	226 + Q	dissoc.*	(343*)
$PtI_2.6NH_3$	c	396 + Q	dissoc.*	(343*)
$Pt(NH_3)_4SO_4$	aq.	1303.4	N	(976)
Ag_2PtCl_6	c	544	$H_2PtCl_6 + AgNO_3$	(815)
Ag_2PtBr_6	c	407	$H_2PtBr_6 + AgNO_3$	(815)
Ruthenium				
Ru	c	0	Def.	
RuO_2	c	220	dissoc.*	(852*)
$RuCl_3$	c	263	dissoc.*	(852,* 1056*)
Palladium				
Pd	c	0	Def.	
PdO	c	90	dissoc.*	(1054*)
Pd_2H	c	74.2	$H_2 + Pd$; &	(357, 445,* 736*)
$Pd(OH)_2$	ppt.	384	$K_2PdCl_4 + KOH$; &	(556, 976)
$Pd(OH)_4$	ppt.	703	$K_2PdCl_6 +$	(976)
$PdCl_2$	c	182	KOH+KCl	(556, 976)
$PdCl_4^=$	aq.	532	K_2PdCl_4	
$PdCl_6^=$	aq.	707	K_2PdCl_6	
H_2PdCl_4	aq.	531	+KOH	(976)
H_2PdCl_6	aq.	709	$N = H_2PtCl_6$	
$PdBr_2$	c	117	Pd + Br; &	(556)
$PdBr_4^=$	aq.	367	K_2PdBr_4	
PdI_2	c	75	$PdI_2 + H_2O$	analogy
$PdI_2.H_2O$	ppt.	374	$K_2PdCl_4 + KI$; &	(556, 976)
$PdCl_2.2NH_3$	c	441	$PdCl_2 + NH_3$; &	(540)
$PdCl_2.4NH_3$	c	662	+HCl; &	(540)
$PdI_2.2NH_3$	c	309	$PdI_2 + NH_3$	(540)
$PdI_2.4NH_3$	c	509	+HI; &	(540)
$Pd(CN)_2$	c	− 205	$K_2PdCl_4 + KCN$; &	(556)
Manganese[a]				
$Mn_{(\alpha)}$	c		Tr.; $5.5^{1100}_{(\beta)}$	(1069)
$Mn_{(\beta)}$	c	0	Def.	
$Mn_{(from\ amalgam)}$	amorp.	− 15	+HCl	(472)
Mn^{++}	aq.	208	$MnCl_2$	
Mn^{+++}	aq.	105	$MnBr_2$	
MnO	c	380	$+O_2$	(619)
MnO_2	c	525	dissoc.; &	(619)
	amorp.	500	$+Na_2O_2$	(712)
$MnO_{2(hydrated\ ppt.)}$	amorp.	485	$KMnO_4 + MnSO_4$; &	(976)
Mn_2O_3	c	950	$+O_2$; &	(699)
$MnO_4^=$	aq.	516	$KMnO_4$	
Mn_3O_4	c	1372	Mn + O	(619, 893)
$HMnO_4$	aq.	516	N = HCl	(976)
$Mn(OH)_2$	ppt.	684	$MnSO_4 + KOH$; &	(976)
$Mn(OH)_3$	ppt.	920	$MnF_3 + NaOH$	(793)
MnF_2	aq.	862	$AgF + MnCl_2$	(793)
MnF_3	aq.	1090	ions	
$MnCl_2$	c	471.6	67.0^{18}_{350}	(976)
	400	539	dil.	(976)
	100	537	Mn + HCl	(472, 976)

[a] $MnCl_{2(conc.)} + nHCl_{(conc.)} + Cl_{2(gas)} = MnCl_4.nHCl$; $\Delta Q = 9.2$ (99). $MnCl_2.2H_2O$, NH_4Cl solid solutions, v. (371). Manganese salt ammines (332, 335).

Formula	State	Q, kj	Method	Lit.
Manganese.—(*Continued*)				
$MnCl_2.2H_2O$	c	1076	34.3_{300}	(371, 900)
$MnCl_2.4H_2O$	c	1677	6.4^{18}_{400}	(976)
$MnBr_2$	c	380	67 (analogy)	
	aq.	447	ions	
$MnBr_2$ (?)	aq.	456	Mn + Br	(350)
MnI_2	aq.	320	ions	
MnS	ppt.	198	$MnSO_4 + Na_2S$; &	(60, 976)
	c	250(?)	Mn + S	(1019)
$MnSO_4$	c	1034	57.7^{18}_{400}	(458, 976)
	400	1092.3	$H_2SO_4 + MnCl_2$; &	(976)
	200	1092.6	dil.	
	100	1091.9	dil.	
	50	1091.2	dil.	
	20	1090.1	dil.	
$MnSO_4.H_2O$	c	1345	32.6^{18}_{400}	(976)
$MnSO_4.5H_2O$	c	2523	0.2^{18}_{400}	(219, 458, 976)
$MnSO_4.7H_2O$	c	3117	dissoc.*	(219)
MnS_2O_6	400	1355	ions	
$MnS_2O_6.6H_2O$	c	3081	-8.1^{18}_{400}	(976)
MnSe	ppt.	114(?)	$MnSO_4 + Na_2Se$	(350)
	c	100	$+Br_2$	(350)
MnN_6	c	− 386	dissoc.	(1113)
$Mn(NO_3)_2$	c	570	53.1^{14}_{300}	(482)
	400	624	$Ba(NO_3)_2 + MnSO_4$	analogy
	6	615.6	→c	(1105)
	3	613	analogy	(1105)
$Mn(NO_3)_2.3H_2O$	c	1499	→liq.	(732)
$Mn(NO_3)_2.6H_2O$	c	2367	-25.7^{18}_{400}	(976)
$MnCl_2.NH_3$	c	608	dissoc.*	(190*)
$MnCl_2.2NH_3$	c	733	dissoc.*	(190*)
$MnCl_2.2NH_4Cl.2H_2O$	c	1730	−23.8	(371)
$MnCl_2.6NH_3$	c	1125	dissoc.*	(190,* 332*)
$MnBr_2.NH_3$	c	518	dissoc.*	(190*)
$MnBr_2.2NH_3$	c	649	dissoc.*	(190*)
$MnBr_2.2NH_4Br$	400	700	mix.	(1012)
$MnBr_2.6NH_3$	c	1072	dissoc.*	(190,* 334*)
$MnSO_4.(NH_4)_2SO_4.6H_2O$	c	4002	−41	(458)
$Mn_3(PO_4)_2$	coll.	3081	$MnCl_2 + Na_2HPO_4$	(129)
	c	3068	$MnCl_2 + Na_2HPO_4$; &	(129, 568, 569)
Mn_3C	c	52	$+O_2$	(619, 893, 997)
$MnCO_3$	c	891	$+O_2$	(619, 1018)
	ppt.	872	$MnCl_2 + K_2CO_3$; &	(58, 976)
MnC_2O_4	ppt.	1086	$MnCl_2 + K_2C_2O_4$	(55)
$Mn(CHO_2)_2$	c	1014	18^{24}_{500}	(55)
	aq.	1033	+KOH	(55)
$Mn(CHO_2)_2.2H_2O$	c	1617	-12^{24}_{300}	(55)
$Mn(C_2H_3O_2)_2$	c	1142	51^{17}_{500}	(976)
	aq.	1194	N	(55)
$Mn(C_2H_3O_2)_2.4H_2O$	c	2331	7^{16}_{600}	(976)
$MnSiO_3$	c	1253	222.1 (∞% HF)	(740)
	gls.	1217	$MnCO_3 + SiO_2$	(619, 740, 1019)
$MnBr_2.2HgBr_2$	8400	773	mix.	(1012)
$MnBr_2.HgBr_2$	4400	616	mix.	(1012)
$2MnBr_2.HgBr_2$	4400	1075	mix.	(1012)
Iron[a]				
$Fe_{(\alpha)}$	c	0	Def.	
$Fe_{(\beta)}$	c		Tr.; $1.3^{728}_{(\alpha)}$	(611, 774, 936, 1071)
$Fe_{(\gamma)}$	c		Tr.; $1.4^{919}_{(\beta)}$	(610, 611, 774, 818)

[a] Fe_2O_3; heat of hydration (717). Reciprocal heat of mixing of $Fe_2(SO_4)_3$ solutions with $Cu(NO_3)_2$; $Zn(Ac)_2$; $Zn(NO_3)_2$; $MnCl_2$; $Mn(Ac)_2$; $FeSO_4$; $MnSO_4$ (51, 69). Heat of dissociation of ammines of $FeBr_2$ and FeI_2; $Fe_2(SO_4)_3.12NH_3$; $FeBr_3.6NH_3$; $FeCl_3.6NH_3$; $FeSO_4.6NH_3$; $K_2FeCl_5.6NH_3$; heat of dissociation (335, 343).

Formula	State	Q, kj	Method	Lit.
		Iron.—(*Continued*)		
$Fe_{(s)}$	c		Tr.; $0.42^{1400}_{(?)}$	(697, 818, 819, 1069)
Fe^{++}	aq.	87	$FeCl_2$	
Fe^{+++}	aq.	40	$FeCl_3$	
FeO	c	268	$+H_2$;* &	(327,* 618, 715, 893,* 912,* 977, 993*)
Fe_2O_3(calcined)	amorp.	802	$+Na_2O_2$	(618, 619, 715, 912,* 993*)
Fe_2O_3(ordinary)	c	798	Tr.; $4^{18}_{\text{(calcined)}}$	(618)
Fe_2O_3(fused)	c	1113	Fe + O; &	(34.5, 398, 327,* 715, 892)
Fe_3O_4	c		Tr.; $0.4^{748}_{(II)}$	(609, 1041)
Fe_3O_4(II)	c		Tr.; $2.4^{485}_{(III)}$	(609)
Fe_3O_4(III magnetite)	c	1117	$+Na_2O_2$	(715)
$Fe(OH)_2$	ppt.	568.6	$FeCl_2$ + NaOH	(976)
$Fe(OH)_3$	ppt.	826	$FeCl_2$ + NaOH	(793)
FeF_2	1200	741	$FeCl_2 + AgF$	(793)
FeF_3	150	1015	$FeCl_3 + AgF$; &	(749, 793)
	1200	1018	$FeCl_3 + AgF$	(793)
$FeCl_2$	c	342.6	74.9^{19}_{400}	(976)
	400	417.5	Fe + HCl	(869, 976)
$FeCl_2.2H_2O$	c	953	36^{20}_{400}	998
$FeCl_2.4H_2O$	c	1550	11.5^{18}_{400}	(556)
$FeCl_3$	c	403	633	624
	1000	536	$FeCl_2$ + HClO; &	(898, 976)
	200	532	dil.	624
	100	528	dil.	
	50	515	dil.	
	20	430	dil.	(793)
$FeCl_3.2.5H_2O$	c	1163	88^{18}_{1200}	(898, 900)
$FeCl_3.6H_2O$	c	2229	24^{21}_{1200}	(898, 900)
$Fe(ClO_3)_3$	600	282	$Ba(ClO_3)_2$ + $Fe_2(SO_4)_3$	(976)
$FeCl_3.2HCl$	500	864.4	$FeCl_2$ + HClO; & ions	(793, 976)
$FeBr_2$	aq.	326		
$FeBr_3$	1000	398	ions; &	(356)
FeI_2	aq.	199	ions	
FeI_3	1000	207	ions	
FeS	c	96.5	Fe + S; &	(553,* 662, 779)
	ppt.	98	$FeSO_4$ + Na_2S	(60, 976)
FeS(natural)	c	80	$+Na_2O_2$	(715)
FeS(pyrite)	c	149	Na_2O_2; &	(577,* 715)
FeS(marcasite)	c	149	$+Na_2O_2$	(715)
$FeSO_4$	c	909.1	62.36^{14}_{110}	(417, 976)
	400	970.7	+HCl	(976)
	200	970.5	+HCl; &	(976)
$FeSO_4.H_2O$	c	1226.1	$31.5^{\ 3}_{200}$	417
$FeSO_4.4H_2O$	c	2109.4	6.7^{14}_{200}	(417)
$FeSO_4.7H_2O$	c	2992.7	-18.1^{14}_{200}	(283, 417, 458, 976)
$Fe_2(SO_4)_3$	1200	2685.8	$Fe_2(SO_4)_3$ + $BaCl_2$; &	(69, 822,* 961, 976)
	400	2685	dil.	(21, 624, 976)
	300	2684	dil.	
	150	2682	dil.	
	50	2661	dil.	
$Fe_2(SO_4)_3.3H_2SO_4$	1200	3302	$Fe_2(SO_4)_3$ + H_2SO_4	69
FeSe	c	80	+Br	(356)
	ppt.	60	$FeSO_4$ + Na_2S	356
FeTe	c	32	+Br	(351)
$FeNO^{++}$	aq.	40	$Fe,NO(SO_4)$	
$Fe(NO_3)_2$	aq.	503	ions	
$Fe(NO_3)_3$	800	663	N	(65)
	200	667	dil.	

Formula	State	Q, kj	Method	Lit.
		Iron.—(*Continued*)		
$Fe(NO_3)_3.9H_2O$	c	3276	-33^{18}_{25}	(55)
$FeNOCl_2$	aq.	372	$FeCl_2$ + NO; &	(437, 661)
$FeCl_2.NH_3$	c	483	dissoc.*	(190)
$FeCl_2.2NH_3$	c	614	dissoc.*	(190)
$FeCl_2.6NH_3$	c	1027	dissoc.*	(332)
$FeNOSO_4$	aq.	923	$FeSO_4$ + NO	(437, 661)
$FeSO_4.(NH_4)_2SO_4.6H_2O$	c	3881	−41	(458)
$Fe_2(SO_4)_3.(NH_4)_2SO_4$	1000	1919	mix.	(51)
$NH_4Fe(SO_4)_2.12H_2O$	c	5423	−69	(48.1)
Fe_3C	c	− 19.25	$+CO_2$;* &	(691,* 892,* 993,* 997)
$FeCO_3$	ppt.	75.0	Na_2CO_3 + $FeSO_4$	(58)
	c	775	dissoc.*	(618*)
$Fe_2(C_2O_4)_3$	100	2553	+KOH; &	(624)
	400	2552	+KOH; &	(624)
$Fe(C_2H_3O_2)_3$	1800	1495	$Ba(C_2H_3O_2)_2$ + $Fe_2(SO_4)_3$	(51, 976)
	600	1500	dil.	(51)
	300	1501	dil.; &	(70)
$Fe(CN)_5^{---}$	aq.	− 613	$K_3Fe(CN)_6$	
$Fe(CN)_6^{---}$	aq.	− 510	$K_3Fe(CN)_6$	
$Fe_4(Fe(CN)_6)_3$	ppt.	−1335	$K_4Fe(CN)_6$ + $FeSO_4$; &	(70)
$FeCO(CN)_5^{---}$	aq.	− 181	$K_3FeCO(CN)_5$	
$Fe_2CO(CN)_5$	c	− 393	$+O_2$	(744)
$HFe(CN)_5^{--}$	aq.	− 614	$K_2HFe(CN)_6$	
$HFe(CN)_6^{---}$	aq.	− 510	$K_3HFe(CN)_6$	
$H_2Fe(CN)_6^{--}$	aq.	− 617	$KH_2Fe(CN)_6$	
$H_2Fe(CN)_5^{--}$	aq.	− 511	$K_2H_2Fe(CN)_6$	
$H_2Fe(CN)_6$	aq.	− 620	N	(555)
$H_2Fe(CN)_6^{--}$	aq.	− 511	$KH_2Fe(CN)_6$	
$H_4Fe(CN)_6$	c	− 514	1.7^{19}_{200}; &	(277)
	aq.	− 512	$H_2Fe(CN)_6$ + Br_2; &	(70, 277, 555)
$(NH_4)_4Fe(CN)_6$	aq.	18	N	(555)
$(NH_4)_4Fe(CN)_6.3H_2O$	c	904	-28^{24}	(555)
$H_2FeCO(CN)_5$	aq.	− 181	22^{19}_{1600}	(744)
$H_2FeCO(CN)_5.H_2O$	c	83	$+O_2$	(744)
$H_4Fe(CN)_6.(C_2H_5)_2O$	c		255^{13}_{KOH}	(277)
Fe_2Si	c	− 80	$+O_2$; &	(258, 259, 775, 997)
$FeSiO_3$	c	1107	$FeCO_3$ + SiO_2; &	(618, 619, 1018)
$ZnFe(CN)_6$	c	− 167	$K_4Fe(CN)_6$ + $ZnSO_4$	(555)
		Cobalt*		
$Co_{(II)}$	c	0	[illegible]	
$Co_{(III)}$	c		Tr.; $0.33^{1000}_{(II)}$	(818, 1069)
Co^{++}	aq.	69	$CoCl_2$	
CoO	c	241	$+O_2$	(322, 372, 712)
	amorp.	210	$+Na_2O_2$	(712)
Co_3O_4	c	806	$+Na_2O_2$	(712)
$Co(OH)_2$	ppt.	537	$CoSO_4$ + NaOH; &	(976)
$Co(OH)_3$	ppt.	918	$Co(OH)_2$ + NaOCl; &	(976)
CoF_2	aq.	723.2	$CoCl_2 + AgF$	(793)
$CoCl_2$	c	322.0	77.2^{17}_{400}	(976)
	400	399.2	Co + HCl	(181, 976)
$CoCl_2.2H_2O$	c	930.3	41.2^{23}_{400}	(900)
$CoCl_2.6H_2O$	c	2128.2	-11.9^{18}_{400}	(976)
$CoBr_2$	c	230	77; &	(301)
	aq.	307	Co + Br_2	(301, 350)
$CoBr_2.6H_2O$	c	2030	− 5.4	824
CoI_2	aq.	179	ions; &	(813)
CoS	ppt.	83	Na_2S + $CoSO_4$	(553, 976)
CoS_2	ppt.	167 (?)	analogy	
$CoSO_4$	800	942.6	+HCl	(976)
	200	941.6	+HCl	(976)

* CoI_2 ammines, heat of dissociation (183, 190). $CoCl_2.(NH_3)_6$, heat of dissociation (180). $CoSO_4$ ammines, heat of dissociation (335). $CoSO_4(NH_4)_2SO_4.6H_2O$, heat of dissociation (262).

Formula	State	Q, kj	Method	Lit.
Cobalt.—(*Continued*)				
$CoSO_4.7H_2O$	c	2960	-14.9^{19}_{800}	(976)
CoSe	c	56	$+Br_2$	(350)
	ppt.	48	Na_2Se + $CoSO_4$	(350)
CoTe	c	48	$+Br_2$	(351)
$Co(NO_3)_2$	c	436	50^{18}_{300}	(482)
	g	470	→c	(1105)
	aq.	486	ions	
$Co(NO_3)_2.6H_2O$	c	2223	-20.8^{18}_{400}	(976)
$[Co.5NH_3.H_2O]^{+++}$	aq.	747	$[Co.5NH_3.H_2O](NO_3)_3$	
$[Co.5NH_3.NO_3]^{++}$	aq.	667	$[Co.5NH_3.NO_3](NO_3)_2$	
$[Co.5NH_3.NO_3](NO_3)_2$	c	1146	-62.4^{25}	(602)
	aq.	1084	$+Na_2S$ = Co_2S_3 + etc.	(602)
$[Co.5NH_3.H_2O](NO_3)_3$	c	1437	-64.4^{25}	(602)
	aq.	1372	$+Na_2S$ = Co_2S_3 + etc.	(602)
$CoCl_2.NH_3$	c	457	dissoc.;* &	(183*)
$CoCl_2.2NH_3$ (α rose)	c	581	dissoc.*	(183)
$[Co.5NH_3.Cl]^{++}$	aq.	613	$[Co.5NH_3.Cl]Cl_2$	
$[Co.5NH_3.Cl]Cl_2$	c	996	-52.0^{25}	(602)
	aq.	943	$+Na_2S$ = Co_2S_3 + etc.	(602)
$CoCl_2.6NH_3$	c	1000	dissoc.*	(183,* 190,* 332)
$[Co.5NH_3.H_2O]Cl_3$	c	1265	-27.0^{25}	(602)
	aq.	1238	$+Na_2S$ = Co_2S_3 +	(602)
$CoBr_2.NH_3$	c	367	dissoc.*	(183*)
$CoBr_2.2NH_3$	c	503	dissoc.*	(183*)
$(NH_4)_2CoBr_4$	aq.	904.2	$CoBr_2$ + NH_4Br	(1012)
$[Co.5NH_3.Br]^{++}$	aq.	575	$[Co.5NH_3.Br]Br_2$	
$[Co.5NH_3.Br]Br_2$	c	867	-53.0^{25}	(602)
	aq.	814	$+Na_2S$ = Co_2S_3 + etc.	(602)
$CoBr_2.6NH_3$	c	963	dissoc.*	(183,† 334)
$[Co.5NH_3.H_2O]Br_2$	c	1145	-38.6^{25}	(602)
	aq.	1107	$+Na_2S$ = Co_2S_3 + etc.	(602)
$Co(C_2H_5SO_4)_2$	aq.	1872	$CoSO_4$ + $Ba(C_2H_5SO_4)_2$	(976)
$\frac{1}{2}CoBr_2.HgBr_2$	4200	316	mix.	(1012)
$CoBr_2.HgBr_2$	4400	475	mix.	(1012)
$2CoBr_2.HgBr_2$	4800	791	mix.	(1012)
Nickel[a]				
$Ni_{(\alpha)}$	c	0	Def.	
$Ni_{(\beta)}$	c		Tr.; $0.3^{355}_{\alpha)}$	(610, 611, 818, 1041, 1045, 1069)
Ni^{++}	aq.	64	$NiCl_2$	
NiO	c	242	Ni + O;* &	(322, 712, 784, 894, 993,* 1055*)
$Ni(OH)_2$	ppt.	543.2	$NiSO_4$ + KOH; &	(976)
$Ni(OH)_3$	ppt.	823	$Ni(OH)_2$ + NaOCl	(976)
NiF_2	aq.	717.8	$NiCl_2$ + AgF	(740, 793)
$NiCl_2$	c	313.8	80.2^{18}_{400}	(976)
	800	394.5	dil.	
	400	394.1	Ni + HCl	(976)
	200	393.4	dil.	(976)
	100	392.5	dil.	
	50	391.2	dil.	
	20	386.7	dil.	
$NiCl_2.2H_2O$	c	92.3	43^{19}_{400}	(900)
$NiCl_2.6H_2O$	c	2115.7	-4.8^{19}_{400}	(976)
$NiBr_2$	c	223	79; &	(301)
	aq.	303	ions; &	(301, 350)
$NiBr_2.3H_2O$	c	1160	1.0	(301)

[a] For other ammines (190, 333, 341). $NiSO_4(NH_4)_2SO_4.6H_2O$, heat of dissociation (262).

Formula	State	Q, kj	Method	Lit.
Nickel.—(*Continued*)				
NiI_2	aq.	175	ions	
NiS	ppt.	87	$NiSO_4$ + Na_2S	(976)
$NiSO_4$	400	950.2	$NiCl_2$ + H_2SO_4	(976)
$NiSO_4.7H_2O$	c	2971.8	-17.8^{19}_{800}	(976)
NiS_2O_6	aq.	1214	ions	
$NiS_2O_6.6H_2O$	c	2941	-10.1^{19}_{400}	(976)
NiSe	c	56	$+Br$	(350)
	ppt.	62	$NiSO_4$ + Na_2Se	(350)
NiTe	c	45	$+Br$	(350)
$NiN_6.H_2O$	c	− 133	dissoc.	(1113)
$Ni(NO_3)_2$	c	430	49^{18}_{280}	(482)
	400	479	ions	
$Ni(NO_3)_2.6H_2O$	c	2227.5	-31.3^{18}_{400}	(976)
$NiCl_2.NH_3$	c	450	74_{HCl}; &	(182)
$NiCl_2.2NH_3$	c	575	82_{HCl}; &	(182, 332†)
$NiCl_2.6NH_3$	c	1041	185_{HCl}; &	(182, 332†)
$NiBr_2.NH_3$	c	356	dissoc.*	(190†)
$NiBr_2.2NH_3$	c	488	dissoc.*	(190†)
$NiBr_2.6NH_3$	c	928	dissoc.*	(190,† 334†)
Ni_3C	c	− 16e	$+O_2$	(894)
$Ni(CN)_2$	c	− 97.3	$NiSO_4$ + KCN; &	(1010, 1011)
$Ni(CN)_4^{=}$	aq.	− 338.4	$K_2Ni(CN)_4$	
$NiBr_2.2HgBr_2$	4200	628	mix.	(1012)
$2NiBr_2.HgBr_2$	4400	470	mix.	(1012)
Tungsten[a]				
W	c	0	Def.	
$W_{(wire)}$	c	0	$W + O_2$	(645)
WO_2	c	528	$WO_3 + H_2$*	(307, 645)
WO_3	c	801	$W + O_2$; &	(307, 645, 707, 730.5, 1039)
W_2O_5	c	1302	$+H_2O$	(645)
H_2WO_4	c	1172	dissoc.*	(530*)
	aq.	1172	Na_2WO_4 + H_2SO_4	(820)
$WO_3.H_2O_2$	aq.	1363	H_2WO_4 + H_2O_2	(820)
$WO_3.2H_2O_2$	aq.	1514	H_2WO_4 + H_2O_2	(820)
$WO_3.3H_2O_2$	aq.	2126	H_2WO_4 + H_2O_2	(820)
Uranium				
U	c	0	Def.	
UO_2	c	1074	$+Na_2O_2$	(714)
UO_2^{++}	aq.	1010	UO_2Cl_2	
UO_3	c	1214	$+Na_2O_2$	(714)
U_3O_8	c	3537	$+Na_2O_2$; &	(714)
$UO_3.\frac{1}{2}H_2O$	c	1357	dissoc.*	(530*)
$UO_3.H_2O$	c	1520	$62.1_{HNO_3(100)}$	(421, 530)
$UO_3.1\frac{1}{2}H_2O$	c	1672	dissoc.*	(530*)
$UO_3.2H_2O$	c	1820	$51.8_{HNO_3(100)}$	(7, 421, 530)
$UO_4.2H_2O$	c	1841	H_2O_2 + UO_2SO_4	(820)
$UO_2.Cl_2$	aq.	1340	$UO_3.2H_2O$ + HCl; &	(7)
$UO_2.Cl_2.H_2O$	c	1600	25^{18}_{1000}	(7)
UO_2SO_4	aq.	1881	$UO_3.2H_2O$ + H_2SO_4; &	(7, 820)
$UO_2SO_4.3H_2O$	c	2720	21^{18}_{1000}	(7)
$UO_2(NO_3)_2$	c	1348	79^{12}_{220}	(421, 667)
	aq.	1427	$UO_3 + HNO_3$; &	(421)
$UO_2(NO_3)_2.H_2O$	c	1663	49.7^{12}_{220}	(421)
$UO_2(NO_3)_2.2H_2O$	c	1979	21.1^{12}_{220}	(421, 667)
$UO_2(NO_3)_2.3H_2O$	c	2278	7.7^{12}_{220}	(7, 296, 421, 667)
$UO_2(NO_3)_2.6H_2O$	c	3167	-22.8^{12}_{220}	(421)
UC_2	c	121	$UO_2 + C$	(514)
$UO_2(C_2H_3O_2)_2$	aq.	1994	ions	

[a] $Hg + Cl^- + W(CN)_8^{---}$ = $HgCl + W(CN)_8^{----}$; $\Delta Q = 70.5$ (1085*).

Formula	State	Q, kj	Method	Lit.
Uranium.—(*Continued*)				
$UO_2(C_2H_3O_2)_2.2H_2O$	c	2585	-18^{18}_{1000}	(7)
$UO_2(C_2H_3O_2)_2.NH_4C_2H_3O_2.6H_2O$	c	4353	-16^{18}_{1000}	(7)
UO_2CrO_4	aq.	1862	ions	
$UO_2CrO_4.5\frac{1}{2}H_2O$	c	3463	-26^{18}_{1000}	(7)
Vanadium[a]				
V	c	0	Def.	
VO_3^-	aq.	1066	KVO_3	
VO_4^-	aq.	1006	KVO_4	
VO_5^-	aq.	944	KVO_5	
V_2O_2	c	875	$+Na_2O_2$	(714, 891, 895)
V_2O_3	c	1463	$+Na_2O_2$	(714, 891)
V_2O_4	c	1712	$+Na_2O_2$	(714)
V_2O_5	c	1830	$+Na_2O_2$; &	(714, 891)
VCl_2	c	616	$+O_2$	(891)
VCl_3	liq.	783	$+O_2$	(891)
VCl_4	liq.	678	$+NaHO_2$	(891)
$VOCl_3$	liq.	842	$+NaHO_2$	(891)
Tantalum				
Ta	c	0	Def.	
Ta_2O_5	c	1256	$Ta + O_2$	(730.5)
Chromium[b]				
Cr_α	c	0	Def.	
Cr_β	c		Tr.; 0.54^{480}_{α}	(611)
$[Cr]^{+++}_{(blue)}$ = $(Cr.6H_2O)^{+++}$	aq.	256	$[Cr]Cl_3$	
CrO_3	c	569	10.3^{18}_{80}	(250, 733, 899)
$CrO_{3(fused)}$	c	583	$+Na_2O_2$	(707, 716)
CrO_3	80.0	579.2	N, Na_2CrO_4	(120, 899, 976)
	49.9	579.0	dil.	(250, 733)
	25.2	578.6	dil.	
	10.1	577	dil.	
	4.03	574.4	dil.	
	3.32	573.0	dil.	
$CrO_4^=$	aq.	853	Na_2CrO_4	
Cr_2O_3	c	1119	$+Na_2O_2$	(707, 716)
	amorp.	1114	$+Na_2O_2$	(707, 716)
	hydrated	1200	$+Na_2O_2$	(707, 716)
$Cr_2O_7^=$	aq.	1438	$K_2Cr_2O_7$	
$Cr_3O_{10}^=$	aq.	2023	$K_2Cr_3O_{10}$	
H_2CrO_4	aq.	865	$=CrO_3$ aq.	
$[Cr](OH)_3$	ppt.	1029	$[CrCl_2]Cl$ + NaOH	(842)
$[CrOH](OH)_2$(from $[CrOH]Cl_2$)	ppt.	1011	+HCl = $[Cr]Cl_3$	(842)
$[Cr(OH)_2]OH$	ppt.		+HCl; ΔQ = 42	(842)
$[Cr]F_{3(violet)}$	aq.	1227.0	+NaOH	(793)
$H_3[Cr]F_6$	aq.	2177	$HF + [Cr]F_3$	(793)
$CrCl_2$	c	417	78	(842)
	aq.	495	$+ O_2 =$ $[CrOH]Cl_2$	(842)
$[Cr]Cl_{3(violet)}$	aq.	752	$[Cr](OH)_3$ + HCl	(842)
$[CrCl_2]Cl_{(green)}$	aq.	712	$K_2Cr_2O_7$ + HCl + KI; &	(122, 976)
$CrCl_2.4H_2O$	c	1631	8	(842)
$CrCl_{3(rose)}$ (forms a green solution)	c	584	128	(842)
$CrCl_3.6H_2O_{(green)}$ = $(CrCl_2.4H_2O)Cl.2H_2O$	c	2429	$-0.2_{150(to\ green)}$	(841)

[a] $NaOH + V_4F_4$ (793). $V_2O_4.H_2O + H_2SO_4$ (431).

[b] $(Cr(NH_3)_6NO_3)Br_3$; $(Cr(NH_3)_6NO_3)SO_4$; $CrCl_2.6NH_3$; $CrCl_2.3NH_3$; heat of dissociation (343). Chromium probably has the coordination number of 6 in all chromic compounds listed. Where the coordination number is not filled out (shown by square brackets) the missing part is water molecules. In calculating heats of formation, the molecular weight taken has been that shown (*i.e.*, *Q* does not include heat of formation of water molecules not shown).

Formula	State	Q, kj	Method	Lit.
Chromium.—(*Continued*)				
$CrCl_3.6H_2O_{(gray)}$ = $(Cr.6H_2O)Cl_3$	c	2416	$50.3_{(to\ blue)}$	(841)
$CrCl_3.10H_2O$ = $(Cr.4H_2O.Cl)Cl_2.6H_2O$	c	3574	0	(518)
$(Cr.4H_2O.Cl)Cl_2$	c	1822	35	(518)
CrO_2Cl_2	gas	513.5	liq.	(37)
	liq.	549	$+H_2O$	(87, 88, 119, 724)
$[Cr]Cl(OH)_{2(violet)}$	aq.	921	+HCl*	(199*)
$[Cr]Cl_2OH_{(violet)}$	aq.	834	+HCl*	(199*)
$[CrOH]Cl_{2(from\ CrCl_2+O_2)}$	aq.	746	+NaOH = $[CrOH](OH)_2$	(842)
$[Cr]Br_{3(blue)}$	aq.	613	+NaOH	(842)
$[CrBr_2]Br_{(green)}$	aq.	565	+NaOH	(842)
$(Cr.4H_2O.Br_2)Br.2H_2O_{(green)}$	c	2279	$+2.8_{250}$	(842)
$(Cr.6H_2O)Br_3$	c	2270	−60.0	(842)
$[Cr]_2(SO_4)_{3(violet)}$	aq.	3155	$[Cr](OH)_3 + H_2SO_4$	(69, 293, 976)
$[Cr_2SO_4]_2(SO_4)_2$	aq.	3135	+KOH	(293)
$[Cr_2(SO_4)_2]SO_4$	aq.	3106	+KOH	(293)
$Cr_2(SO_4)_3$(modified by heat) = $[Cr_2(SO_4)_3].(OH)_2 + H_2SO_4$ (?)	aq.	3076	+NaOH; &	(843)
$[Cr_2(SO_4)_3]_{(green)}$	aq.	3059	+NaOH	(843)
$Cr_2(SO_4)_3.14H_2O_{(violet)}$ = $(Cr.6H_2O)_2(SO_4)_3.2H_2O$	c	7119	42.3	(918)
$(Cr.6H_2O)_2(SO_4)_3.3H_2O$	c	7412	34.7	(918)
$Cr_2(SO_4)_3.17H_2O_{(violet)}$ = $(Cr.6H_2O)_2(SO_4)_2.5H_2O$	c	7995	26	(843, 918)
$Cr_2(SO_4)_3.6H_2O_{(green)}$	c	4718	56	(843, 918)
$H_2Cr_2(SO_4)_4$	aq.		+2NaOH; ΔQ = 139	(842)
$H_4Cr_2(SO_4)_5$	aq.		+4NaOH; ΔQ = 280	(842)
$H_6Cr(SO_4)_6$	aq.		+6NaOH; ΔQ = 400	(842)
$(NH_4)_2CrO_4$	c	1148	-24^{18}_{700}	(899)
	aq.	1120	N; &	(119, 733)
$(NH_4)_2Cr_2O_7$	c	1758	-54^{16}_{550}	(119, 725, 733)
	600	1705	N	(119, 725, 733)
$CrCl_3.3NH_3$	c	719.2	dissoc.*	(343*)
$CrCl_3.6NH_3$	c	996.0	dissoc.*	(343*)
Cr_3C_2	c	544	$Cr_2O_3 + C$*	(514*)
$PbCrO_4$	c	913	$Pb(NO_3)_2$ + K_2CrO_4	(456)
Molybdenum				
Mo	c	0	Def.	
MoO_2	c	550	Mo + H_2O;* &	(67,* 711)
MoO_3	c	728	Mo + O_2; &	(306, 711, 730.5)
MoO_4	aq.	681	$MoO_3 + H_2O_2$	(725, 820, 821)
$MoO_4^=$	aq.	1020	Na_2MoO_4	(785, 820, 821)
MoO_5	aq.	596	$MoO_3 + H_2O_2$	(785, 820, 821)
$MoO_5^=$	aq.	1303	K_2MoO_5	(785, 820, 821)
H_2MoO_4	c	1034	dissoc.*	(530*)
	aq.	1032	H_2SO_4 + Na_2MoO_4	(820)
H_4MoO_5	c	1337	dissoc.	(820)
$24MoO_3.2SiO_2.4H_2O$	c		+NaOH	(297)
Boron				
B	amorp.	0	Def.	
BO_2^-	aq.	729	$NaBO_2$; &	(946)
BO_3^{---}	aq.	900	Na_2BO_4	

Formula	State	Q. kj	Method	Lit.
		Boron.— *Continued*		
B_2O_2	c (?)	1171	$+KOH$	(86, 88)
	aq.	1202	$=H_3BO_3$	
$B_4O_7^{--}$	aq.	2668	$Na_2B_4O_7$	
H_3BO_3	c	1053	-22.6^{18}_{400}	(86, 88, 976)
	aq.	1030	$BCl_3 + H_2O$	
BF_3	gas	1075	102	(486)
	aq.	1178	$H_3BO_3 + HF$	(976)
BF_4^-	aq.	1498	$N = HCl$	
HBF_4	aq.	1498	$H_3BO_3 + HF$	(746, 976)
BCl_3	gas	373	$B - Cl_2$	(84, 888)
	liq.	392	gas	(84)
BBr_3	liq.	179	350_{aq}	(84)
$(NH_4)BO_2$	200	863	N	(50)
	1320	862.0	dil.	(50)
$(NH_4)_2HBO_3$	300	1241	N	(50)
$(NH_4)_3BO_3$	aq.	1327	N	(50)
		Aluminum[a]		
Al_α	c	0	Def.	
Al_β	c		$Tr\ 0.39^{550}_{\alpha}$	(610, 611)
Al^{+++}	aq.	529	$AlCl_3$	
Al_2O_3(corundum)	c	1676	$+Na_2O_2$	(716)
Al_2O_3(powder)	amorp.	1630	$Al + O_2$; &	(27, 142, 362, 730.5)
$Al(OH)_3$	ppt.	1275	$AlCl_3 + NH_4OH$	(32, 84, 976)
AlF_3	c	1377	analogy	(32)
	aq.	1507	$AlCl_3 + HF$	(794)
AlF_6^{---}	aq.	2474	K_3AlF_6	
H_3AlF_6	aq.	2467.5	$AlF_3 + HF$	(48.1, 794)
$AlF_3.5H_2O$	c	1571	$107_{HF(aq)}$	(32)
$AlF_3.3\frac{1}{2}H_2O$(soluble)	c	2516	-6.9^{15}	(32)
$AlF_3.3\frac{1}{2}H_2O$(insoluble)	c	2518	$+HF$	(32)
$AlCl_3$	c	698	326	(31, 32, 84, 900, 976)
	600	1024	$Al + HCl$	(188, 889, 932, 976)
$AlCl_3.6H_2O$	c	2686	55^{16}_{450}	(900)
$AlBr_3$	c	530	357^{9}_{2000}	(84)
	aq.	887	$+NH_4OH$	(84, 881)
AlI_3	c	298	372^{9}_{2200}	(84)
	aq.	671	$+KCl$	(84)
Al_2S_3	c	1443	314	(897)
$Al_2(SO_4)_3$	c	2996	dissoc.*	(10584)
	aq.	3699	$+BaCl_2$	(318, 976)
$Al_2(SO_4)_3.6H_2O$	c	5181	234	(359)
$Al_2(SO_4)_3.18H_2O$	c	8816	34	(359)
$AlCl_3.8O_2$	c	1030	312.4	(32)
$AlCl_3.5O_2$	c	870	315.0	(32)
$AlCl_3.5H_2S$	c	729	315.0^{15}_{1200}	(32)
AlN	c	550	$+O_2$	(364, 365, 682)
$AlF_3.2NH_4F.1\frac{1}{2}H_2O$	c	2804.8	-35.7	(32)
$AlCl_3.NH_3$	c	904	228^{15}	(32)
$AlCl_3.NH_4Cl$	c	1069	253.1^{15}_{800}	(32)
$AlCl_3.3NH_3$	c	1183	126.8^{15}	(32)
$AlCl_3.5NH_3$	c	1435	37.9^{15}_{2300}	(32)
$AlCl_3.6NH_3$	c	1527	26.6^{15}_{2300}; &	(32, 243†)
$AlCl_3.NH_4Cl.6NH_3$	c	1905	-11.5	(32)
$AlCl_3.9NH_3$	c	1764	33.2; &	(32)
$NH_4Al(SO_4)_2.12H_2O$	c	5900	-40^{11}_{1000}	(359)
Al_4C_3	c	341	$+O_2$	(142, 1104)
$Al_2O_3.SiO_2$(andalusite)	c	2311.8	$+HF$	(756)
$Al_2O_3.SiO_2$(disthene)	c	2309.9	$+HF$	(756)
$Al_2O_3.SiO_2$(sillimanite)	c	2321.4	$+HF$	(756)
$Al_2O_3.2SiO_2$(from kaolinite)	amorp.	4106	$C + O_2$	(276)
$Al_2O_3.2SiO_2.H_2O$(kaolinite)	amorp.	3955	$C + O_2$	(275)
$3Al_2O_3.2SiO_2$(mullite)	c	6127	$+HF$	(756)
Al_4Ti_3	c	2180	$-O_2$	(1028)
$AlCl_3.\frac{1}{2}ZnCl_2$	c	993	393	(32)
$AlCu$	c	28o(?)	$+Br_2$	(879)
$AlCu_2$	c	109	$+Br_2$	(879)
Al_2Cu	c	39o	$+Br_2$	(879, 881)
$AlCl_3.AgCl$	c	834	317	(32)
Al_2Fe	c	105	$155o_{HCl(g)}$	(186)
$AlCo$	c	134	$445_{HCl(g)}$	(186)
Al_2Co	c	360	$2365_{HCl(g)}$	(186)

[a] $AlCl_3$ in liq. $COCl_2$ (440).

Formula	State	Q. kj	Method	Lit.
		Yttrium		
Yt	c	0	Def.	
Yt^{+++}		Q		
$YtCl_3$	c	$306 + Q$	$189\ 9^{16}_{200}$	(677)
	aq.	$496 + Q$	ions	
$Yt_2(SO_4)_3$	aq.	$2586 + 2Q$	$- BaCl_2$	(976)
$Yt_2(SO_4)_3.8H_2O$	c	$4830 + 2Q$	$44\ 7^{24}_{200}$	(976)
$Yt(OH)_3$	ppt.	$711 - Q$	$Yt_2(SO_4)_3 + Ba(OH)_2$	(976)
		Lanthanum		
La	c	0	Def.	
La^{+++}	aq.	751	$LaCl_3$	
La_2O_3	c	1912	$La + O_2$	(597, 738.5, 752)
La_2O_3 "uncondensed"	amorp.	1880	analogy	
La_2O_3 hydrated	amorp.	2000	$352^{5}_{HCl(g)}$ &	(677, 976)
LaH_3	c	670	$-HCl$	(919)
$LaCl_3$	c	1116	181^{6}_{1200}	(677)
	aq.	1247	$La_2O_3 - HCl$	(677)
LaS_2	c	675	133_{HCl}	(178)
La_2S_3	c	1328	390_{HCl}	(178)
$La_2(SO_4)_3$	aq.	4181	$-BaCl_2$	(976)
$La_2(SO_4)_3.8H_2O$	c	6408	17^{4}_{1200}	(976)
$LaAl_4$	c	90o ?	$-O_2$	(751)
		Praseodymium		
Pr	c	0	Def.	
Pr^{+++}	aq.	650	$PrCl_3$	(751)
PrO_2	c	900	$180_{HNO_3,c}$	(1103)
Pr_2O_3	c	1745	$Pr + O_2$	(751)
Pr_6O_{11}	c	5356	$1130_{HNO_3,c}$	(1103)
	amorp.	1726	analogy	(751)
$PrCl_3$	c	1006	140^{5}_{1200}	(675)
	aq.	1146	Pr_2O_3(amorp.) $- HCl$	(675)
$PrCl_3.H_2O$	c	1311	121^{17}_{2000}	(675)
$PrCl_3.7H_2O$	c	3127	22^{25}_{2000}	(675)
$Pr(NO_3)_3$	aq.	1320	$Pr_2O_3 - HNO_3$	(1103)
		Samarium		
Sa	c	0	Def.	
Sa^{+++}	aq.	Q		
Sa_2O_3	c	$462 - Q$	$+HCl$	(675)
Sa_2O_3(from oxalate)	amorp.	$462 - Q$	$+HCl$	(675)
$SaCl_3$	c	$339 - Q$	156_{aq}	(675)
	aq.	$495 - Q$	ions	(675)
$SaCl_3.NH_3$	c	$471 - Q$	dissoc.*	(689*)
$SaCl_3.2NH_3$	c	$586 - Q$	dissoc.*	(689*)
$SaCl_3.3NH_3$	c	$695 - \frac{4}{3}Q$	dissoc.*	(689*)
$SaCl_3.4NH_3$	c	$795 - Q$	dissoc.*	(689*)
$SaCl_3.5NH_3$	c	$894 - Q$	dissoc.*	(689*)
$SaCl_3.8NH_3$	c	$1173 + Q$	dissoc.*	(689*)
$SaCl_3.9\frac{1}{2}NH_3$	c	$1305 + Q$	dissoc.*	(689*)
$SaCl_3.10\frac{1}{2}NH_3$	c	$1473 + Q$	dissoc.*	(689*)
		Neodymium		
Nd	c	0	Def.	
Nd^{+++}	aq.	686	$NdCl_3$	
Nd_2O_3	c	1820	$Nd + O_2$	(751)
	amorp.	1790	analogy	
$NdCl_3$	c	1032	149_{2000}	(674)
	aq.	1181	Nd_2O_3(amorp.) $- HCl$	(674)
NdI_3	c	650	205^{16}_{2000}	(674)
	aq.	855	$Nd_2O_3 - HI$	(678)
Nd_2S_3	c	1099	$-HCl$	(678)
$Nd_2(SO_4)_3$	c	3848	153_{aq}	(678)
	aq.	4001	$H_2SO_4 - Nd_2O_3$	(678, 976)
$Nd_2(SO_4)_3.5H_2O$	c	5397	35	(678)
$Nd_2(SO_4)_3.8H_2O$	c	6262	25_{aq}	(678, 976)
$NdCl_3.NH_3$	c	1163	dissoc.*	(690*)
$NdCl_3.2NH_3$	c	1279	dissoc.*	(690*)
$NdCl_3.4NH_3$	c	1486	dissoc.*	(690*)
$NdCl_3.5NH_3$	c	1584	dissoc.*	(690*)
$NdCl_3.8NH_3$	c	1862	dissoc.*	(690*)
$NdCl_3.11NH_3$	c	2138	dissoc.*	(690*)
$NdCl_3.12NH_3$	c	2200	dissoc.*	(690*)

Formula	State	Q, kj	Method	Lit.
Erbium[a]				
Cerium[b]				
Ce	c	0	Def.	
CeO_2	c	983	Ce + O_2	(520, 730.5, 752)
Ce^{+++}	aq.	690	$CeCl_3$	
$CeCl_3$	60	1178	Ce + HCl_{20}	(194)
	600	1186	analogy	(194)
$Ce_2(SO_4)_3$	aq.	3318	+ $BaCl_2$	(976)
$Ce_2(SO_4)_3.4\frac{1}{2}H_2O$	c		67.5	(976)
$CeAl_4$	c	160	$2596_{HCl(3)}$; &	(194, 751)
Ce_2Al	c	92	$2496_{HCl(3)}$; &	(194, 751)
Beryllium				
Be	c	0	Def.	
Be^{++}	aq.	354	$BeCl_2$	
BeO (low temp.)	c	591	Be + HF	(298, 299, 687, 700)
$Be(OH)_2$	ppt.	865	+ HCl; &	(687, 740, 794, 976)
BeF_2	aq.	1007.9	$BeCl_2$ + AgF	(794)
H_2BeF_4	aq.	1643.0	Be + HF	(298)
$BeCl_2$	c	471	Be + Cl_2	(700)
	aq.	685	214	(687, 824)
	$HCl.9H_2O$	656	185	(1082)
$BeCl_2.4H_2O$	c	787	dissoc.*	(1082*)
$BeBr_2$	c	378	$233_{HCl(3)}$	(1082)
BeI_2	c	282	$262_{HCl(3)}$	(1082)
$BeSO_4$	c	1157	144_{NaOH};* &	(596, 664,† 665.5, 687)
	aq.	1235	+ $BaCl_2$	(687, 976)
$BeSO_4.H_2O$	c	1460	+ H_2O*	(596)
$BeSO_4.2H_2O$	c	1715	8.0^{15}_{1000}	(596, 687)
$BeSO_4.4H_2O$	c	2375	4.6	(596, 687, 824, 976)
$Be(NO_3)_2$	aq.	773	$BeSO_4$ + $Ba(NO_3)_2$	(687)
$BeCl_2.2NH_3$	c	982	dissoc.*	(1082*)
$BeCl_2.4NH_3$	c	1225	$120_{HCl(3)}$	(1082*)
$BeCl_2.6NH_3$	c	1384	dissoc.*	(1082*)
$BeCl_2.12NH_3$	c	1849	dissoc.*	(1082*)
$BeBr_2.4NH_3$	c	1162	$141_{HCl(3)}$	(1082*)
$BeBr_2.6NH_3$	c	1321	dissoc.*	(1082*)
$BeBr_2.10NH_3$	c	1625	dissoc.*	(1082*)
$BeI_2.4NH_3$	c	1085	$146_{HCl(3)}$	(1082*)
$BeI_2.6NH_3$	c	1257	dissoc.*	(1082*)
$BeI_2.13NH_3$	c	1807	dissoc.*	(1082*)
Magnesium				
Mg	c	0	Def.	
Mg^{++}	aq.	461.2	$MgCl_2$	
MgO (bomb)	amorp. (?)	610	Mg + O_2; &	(315, 866, 674, 730.5, 877, 1028)
$Mg(OH)_2$	ppt.	915	$MgSO_4$ + NaOH	(976, 1089)
$Mg(OH)_2$ (brucite)	c	935	+ Na_2O_2	(717)
MgF_2	ppt.	1104	$MgCl_2$ + AgF; &	(464, 465, 793)
$MgCl_2$	c	641	150.6^{16}_{800}	(157.5, 976)
	400	791.5	Mg + HCl	(188, 858, 869, 933, 960, 976)
	200	791.0	dil.	(324, 976)
	100	790.2	dil.	
	50	789.0	dil.	
	20	785.5	dil.	
	10	775.5	dil.	
$MgCl_2.2H_2O$	c	1278	85^{18}_{200}	(900, 976)
$MgCl_2.4H_2O$	c	1894	42^{18}_{200}	(900, 976)
$MgCl_2.6H_2O$	c	2495.8	12.3^{18}_{200}; &	(522, 633, 976)
$MgCl_2.MgO$	c	1762	61_{HCl}	(11)
$MgCl_2.MgO.6H_2O$	c	3379	151_{HCl}	(11)
$MgCl_2.MgO.16H_2O$	c	6310	92_{HCl}	(11)

[a] $2Er(C_2H_3O_2)_{3(1500)} + 3Ba(OH)_{2(400)}$; $\Delta Q^{18} = 107.5$ (976). $Er(C_2H_3O_2)_3.4H_2O + 1500H_2O$; $\Delta Q^{20} = 5.7$ (976).

[b] Mischmetall, 40 % CeO_2, heat of combustion 1 g = 6.926 kj (752).

Formula	State	Q, kj	Method	Lit.
Magnesium.—(*Continued*)				
MgOHCl		804	$MgCl_2$ + H_2O*	(720*)
$MgBr_2$	c	519	181^{15}	(43)
	400	700	ions	
MgI_2	c	363	208	(43)
	aq.	572	ions; &	(976)
MgS	c	344	159^{13}_{HCl}	(897)
$MgSO_3$	c	998	70.6^{12}_{HCl}	(503)
$MgSO_3.3H_2O$	c	1922	4.9^{18}_{HCl}	(503)
$MgSO_3.6H_2O$	c	2809	-23.6^{14}_{HCl}	(503)
$MgSO_4$	c	1260	85^{18}_{400}	(157.5, 458, 806, 810, 665.5, 976)
	400	1344.8	dil.	
	200	1344.6	$MgSO_4$ + $BaCl_2$	(976)
	100	1344.3	dil.	(976)
	50	1344.2	dil.	
	20	1343.0	dil.	
$MgSO_4.H_2O$	c	1575	56^{18}_{400}	(360, 806, 976)
$MgSO_4.2H_2O$	c	1871.0	46.2^{18}_{400}	(976)
$MgSO_4.4H_2O$	c	2471.7	17.7^{18}_{400}	(976)
$MgSO_4.6H_2O$	c	3062.2	-0.6^{18}_{400}	(976)
$MgSO_4.7H_2O$	c	3364.1	-16.2^{18}_{400}	(157.5,° 312,† 429,* 458, 806,° 807, 810, 880, 890, 976)
MgS_2O_6	aq.	1608	$MgSO_4$ + $BaSO_4$	(976)
$MgS_2O_6.6H_2O$	c	3337	-12.4^{19}_{400}	(976)
$Mg(HS)_2$	aq.	491	$Mg(OH)_2$ + H_2S	(976)
Mg_3N_2	c	495	+ HCl; &	(680, 735)
$Mg(NO_3)_2$	400	876.8	$Ba(NO_3)_2$ + $MgSO_4$	(976)
	200	876.5	dil.	(324,† 976)
	100	876.5	dil.	
	50	876.7	dil.	
	20	876.7	dil.	
	15	876.1	dil.	
	12	875.0	dil.	
$Mg(NO_3)_2.6H_2O$	c	2611	-17.7^{18}_{400}	(811, 976)
$(Mg(NH_3)_2)^{++}$	aq.	622	$Mg(NH_3)_2Cl_2$	(128)
$MgCl_2.NH_3$	c	774	dissoc.*	(192*)
$MgCl_2.2NH_3$	c	906	dissoc.*	(192*)
	aq.	953	mix.	(128)
$MgCl_2.6NH_3$	c	1263	dissoc.;* &	(192,* 222, 332*)
$MgBr_2.NH_3$	c	655	dissoc.*	(192*)
$MgBr_2.2NH_3$	c	785	dissoc.*	(192*)
$MgBr_2.6NH_3$	c	1223	dissoc.*	(334*)
$MgI_2.2NH_3$	c	645	dissoc.*	(192,* 334*)
$MgI_2.6NH_3$	c	1116	dissoc.*	(192,* 334*)
$MgSO_4.(NH_4)_2SO_4.2H_2O$	c	3885	+ $4H_2O$	(262)
$MgSO_4.(NH_4)_2SO_4.6H_2O$	c	4254	−41	(458)
$3MgSO_3.(NH_4)_2SO_3.6H_2O$	c	5757	$+37.1_{HCl(200)}$	(503)
$3MgSO_3.(NH_4)_2SO_3.18H_2O$	c	9321	$-93.2_{HCl(200)}$	(503)
$Mg_3(PO_4)_2$	coll.	3830 (?)	$MgSO_4$ + Na_3PO_4	(129)
$MgHPO_4$	coll.	1740	$MgSO_4$ + Na_2HPO_4	(129)
$Mg(NH_4)PO_4.6H_2O$	c	3773	$Mg(NH_3)_2Cl_2$ + Na_2HPO_4	(129)
$MgHAsO_4$	aq.	1351	N	(203)
$MgH_4(AsO_4)_2$	aq.	2263	N	(203)
$Mg_3(AsO_4)_2$	c	3061	N	(203)
$Mg(NH_4)AsO_4.6H_2O$	c	3197	$Mg(NH_3)_2Cl_2$ + H_3AsO_4	(129)
$MgCO_3$	c	1119	$MgSO_4$ + Na_2CO_3	(58, 663, 1004*)
$MgCN_2$	c	248	+ O_2	(427)
$Mg(CN)_2$	aq.	169	$Ba(CN)_2$ + $MgSO_4$	(1007)

Formula	State	Q, kj	Method	Lit.
Magnesium.—(*Continued*)				
$MgSiO_3$	c	1450	$MgO + SiO_2$	(275)
Mg_2Sn	c	205	1092 $FeCl_3$ + HCl(8)	(189)
$MgZn_2$	c	55	+HCl; &	(188, 881, 1030)
$MgCd_{(II)}$	c	38	+HCl; &	(188, 881)
$MgCd_{(I)}$	c		Tr.; $1.2^{136.7}$	(881)
$MgHg_4$	liq.	72.4	+HCl	(960)
$MgBr_2.HgBr_2$	4400	868	mix.	(1012)
$MgBr_2.2HgBr_2$	4200	1025	mix.	(1012)
$2MgBr_2.HgBr_2$	4800	1576	mix.	(1012)
$Mg(CN)_2.Hg(CN)_2$	600	− 50	mix.	(1012)
$Mg(CN)_2.2Hg(CN)_2$	900	− 316	mix.	(1012)
$MgCl_2.2Hg(CN)_2$	1000	248	mix.	(1009)
$MgCl_2.2Hg(CN)_2.6H_2O$	c	2008	43^{15}	(1009)
$MgBr_2.2Hg(CN)_2$	1000	161	mix.	(1009)
$MgBr_2.2Hg(CN)_2.8H_2O$	c	2518	66.8^{14}	(1009)
$MgI_2.2Hg(CN)_2$	100	53	mix.	(1009)
$MgI_2.2Hg(CN)_2.8H_2O$	c	2426	-84^{15}	(1009)
Mg_4Al_3	c	205	+HCl; &	(188, 881)
MgCe	c	54	$1090_{HCl(20)}$	(194)
Mg_3Ce	c	71	$1997_{HCl(20)}$	(194)
Calcium[a]				
Ca	c	0	Def.	
Ca^{++}	aq.	542	$CaCl_2$	
CaO	c	634.9	194.4_{HCl}; &	(436, 617, 976)
$CaO_{(II)}$	c		Tr.; $1.2^{410}_{(I)}$	(585, 808)
$CaO_{(1000°)}$	amorp.	635	194.8_{HCl}	(67, 299, 436, 617, 674)
CaO_2	c	652	79.2_{HCl}	(48,* 387)
$CaO_2.8H_2O$	c	3007	+HCl	(387)
CaH (?)	c	80	dissoc.*	(721)
CaH_2	c	192	346_{HCl}; &	(250, 479, 589, 641.1,* 721)
$Ca(OH)_2$	c	988	128_{HCl}	(321, 589, 662, 976)
	aq.	999.2	+HCl; &	(67, 386, 479, 719, 976)
$Ca(OH)_2.H_2O_2$	c	1217	H_2O_2 + $Ca(OH)_2$	(387)
CaF_2	ppt.	1198	N	(464)
CaCl	c	409	$302^{15}_{HCl(300)}$	(46)
$CaCl_{2(fused)}$	c	798	75.3^{18}_{400}	(32, 157.5,° 316, 360.5,. 623,° 811, 976)
	∞	873.2	dil.	(324, 501.5,° 976, 1003†)
	400	873.0	dil.	
	200	873.0	Ca + HCl; &	(188, 197, 250, 299, 479, 480, 719)
	100	872.3	dil.	
	50	871.8	dil.	
	20	869.3	dil.	
	10	862.5	dil.	
	6	854	$CaCl_2.6H_2O$	(741)
$CaCl_2.H_2O$	c	1110	49^{18}_{300}	(900, 976)
$CaCl_2.2H_2O$	c	1395	42^{18}_{400}	(750,* 884, 976)
$CaCl_2.4H_2O$	c	2010	7.7^{18}_{400}	(750,* 884, 976)
$CaCl_2.6H_2O$	c	2609.1	-19.1^{18}_{400}	(312,* 316, 360.5, 522, 750,* 811, 884, 976)
$CaCl_2.4HCl$	aq.			(501†)
$CaCl_2.2CaO$	c	2115	416_{HCl}	(10)
$CaCl_2.3CaO$	c	2740	616_{HCl}	(10)
$CaCl_2.3CaO.3H_2O$	c	3810	409_{HCl}; &	(10, 966)
$CaCl_2.3CaO.16H_2O$	c	7674	265_{HCl}	(10)
$Ca(ClO)_2$	aq.	760	ions	
$CaOCl_2$	c	748	41.1	(765)
	aq.	789	$+H_2O_2$; &	(535)
$CaOCl_2.H_2O$	c	1043	31.5	(535, 758, 764, 765)

[a] Wollastonite to pseudowollastonite (?) heat of reversion, 1.16 cal per mol (5). Cement, "heat of burning" (753).

Formula	State	Q, kj	Method	Lit.
Calcium.—(*Continued*)				
$CaBr_2$	c	679	102	(811, 976, 1009)
	aq.	782	ions	
$CaBr_2.6H_2O$	c	2503	-4.6^{20}_{400}	(976)
$CaBr_2.3CaO.3H_2O$	c	3718	409^{16}_{HBr}	(964)
$CaBr_2.3CaO.16H_2O$	c	7581	266.0^{20}_{HBr}	(966)
CaI_2	c	538	115.9^{18}_{400}	(411, 811, 976)
	aq.	654	ions	
$CaI_2.8H_2O$	c	2936	7.3^{20}	(966)
$CaI_2.3CaO.16H_2O$	c	7450	265_{HI}	(966)
CaS	c	475	110.0^{11}_{HCl}	(897)
	aq.	501	N	(796)
$CaSO_3.2H_2O$	c	1731	+S	(178)
$CaSO_{4(anhydrite)}$	c	1405	22	(396, 717)
$CaSO_{4(soluble)}$	c	1416.0	11.1	(396, 523, 717)
	aq.	1427	N; &	(976)
$CaSO_4.\frac{1}{2}H_2O$	c	1555	15	(266, 396, 523*)
$CaSO_4.2H_2O$	c	1999.6	−1	(30, 603.5, 976)
CaS_2O_3	∞	1132	ions	
	350	1132.2	dil.	(178)
	230	1132.1	dil.	
	116	1131.5	dil.	
	33.5	1130.4	dil.	
CaS_2O_6	aq.	1688.4	ions	
$CaS_2O_6.4H_2O$	c	2866	-33.3^{18}_{400}	(976)
$Ca(HS)_2$	aq.	575	N	(976)
$CaI_2.4SO_2$	c	1876	dissoc.*	(342*)
CaSe	c	370	146_{HCl}	(350)
CaN_6	c	− 317	dissoc.	(1113)
Ca_3N_2	c	456	1432_{HCl}; &	(478, 479, 735)
$Ca(NO_2)_2.4H_2O$	c	1697	$+Br_2$	(133)
$Ca(NO_3)_2$	c	943	16.5^{19}_{400}	(55, 360.5, 811, 976)
	400	959	ions	(324,† 890†)
	4	961	$\rightarrow Ca(NO_3)_2.4H_2O$	(732, 813)
$Ca(NO_3)_2.2H_2O$	c	1540	dissoc.*	(631*)
$Ca(NO_3)_2.3H_2O$	c	1840	dissoc.*	(631*)
$Ca(NO_3)_2.4H_2O$	c	2134	-30.3^{19}_{400}	(55, 360.5, 811, 976)
$Ca(NH_2)_2$	c	382.9	$426^{10}_{HCl(300)}$	(480)
$Ca(NO_3)_2.Ca(OH)_2$	c	1935	141_{HNO_3}	(1044)
$Ca(NO_3)_2.Ca(OH)_2.2\frac{1}{2}H_2O$	c	2686	104_{HNO_3}	(1044)
$CaCl_2.NH_3$	c	914	dissoc.*	(527*)
$CaCl_2.2NH_3$	c	1023	dissoc.;* &	(527,* 539)
$CaCl_2.4NH_3$	c	1201	+HCl; &	(527,* 539)
$CaCl_2.8NH_3$	c	1550	+HCl; &	(334,* 527,* 539)
$CaBr_2.NH_3$	c	803	dissoc.*	(527,* 539)
$CaBr_2.2NH_3$	c	920	dissoc.*	(527,* 539)
$CaBr_2.4NH_3$	c	1299	dissoc.*	(527,* 539)
$CaBr_2.8NH_3$	c	1473	dissoc.*	(527,* 539)
$CaI_2.NH_3$	c	666	dissoc.*	(527,* 539)
$CaI_2.2NH_3$	c	792	dissoc.*	(527,* 539)
$CaI_2.6NH_3$	c	1209	dissoc.*	(527,* 539)
$CaI_2.8NH_3$	c	1371	dissoc.*	(527,* 539)
$CaSO_4.(NH_4)_2SO_4.H_2O$	c	2877.4	−9.0	(30)
$2CaSO_4.(NH_4)_2SO_4$	c	3991	18.3	(30)
$5CaSO_4.(NH_4)_2SO_4.H_2O$	c	8570	9.7	(30)
$Ca_3(PO_4)_2$	c	4110	Na_3PO_4 + $CaCl_2$; &	(86, 88, 129, 569)
	coll.	4090	N	(86, 88, 129, 569)
$CaHPO_4$	ppt.	1810	N; &	(86, 88, 129, 569)
$CaHPO_4.2H_2O$	c	2393	Na_2HPO_4 + $CaCl_2$	(86, 88, 129, 569)
$CaH_4(PO_4)_2$	ppt.	3110	N	
$Ca_3(AsO_4)_2$	ppt.	3320	N	(86, 88, 129, 201, 569)
$CaHAsO_4$	ppt.	1430	N	(201)

Formula	State	Q, kj	Method	Lit.
Calcium.—(*Continued*)				
$CaH_4(AsO_4)_2$	ppt.	2349	N	(281)
CaC_2	c	61	254.0_{HCl}	279, 427, 595, 894.5)
$CaCO_3$	coll.	1205	$CaCl_2 + Na_2CO_3$	(61)
$CaCO_{3(calcite)}$	c	1209	$CaCl_2 + K_2CO_3$; &	(25, 54, 61, 563,* 564, 617, 976, 1075*)
$CaCO_{3(aragonite)}$	c	1207	+HCl; &	(25, 28, 412, 617)
CaC_2O_4	ppt.	1305	$K_2C_2O_4 + CaCl_2$	(58)
$Ca(CHO_2)_2$	c	1368	2.9^{16}_{360}	(55)
	406	1371	ions; &	(55)
$CaC_4H_4O_4$	c	1705	N	56
	aq.	1789	N	56
$Ca(C_2H_3O_2)_2$	c	1498	29.6_{400}	55, 559)
	aq.	1527	ions; &	55)
$Ca(C_2H_3O_2)_2.H_2O$	c	1789	29.5^{17}_{400}	55)
$Ca(C_2H_5O_2)_2$	c	1847	$168^{15}_{HCl\ (216)}$	(615)
$Ca(C_2H_5O_2)_2.2C_2H_5OH$	c	1584	$154_{HCl\ (240)}$	615)
$3CaO.4C_2H_5OH$	c	1245	789_{HCl}	380
$CaCN_2$	c	356	$-O_2$; &	113, 427, 576, 595, 603, 973)
$Ca(CN)_2$	aq.	255	N	(535)
$3CaO.Ca(CN)_2.15H_2O$	c	6729	393.0_{HCl}	535)
CaSi	c	370	$-O_2$	1037
$CaSi_2$	c	340	$-O_2$	1037
$CaSiO_3$	gla.	1576	$CaCO_3 + SiO_2$	(275, 276, 618, 619)
Ca_2SiO_4	gla.	1810	$CaCO_3 + SiO_2$	(275, 276)
$CaSn_3$	c	130	$1130_{FeCl_3+HCl\ (a)}$	(189)
$CaZn_4$	c	123	$919_{HCl\ (a)}$	137, 881)
$CaZn_{13}$	c	201	$394_{HCl\ (a)}$	197, 881)
$CaZn_2$	c	176	$919_{HCl\ (a)}$	(197)
$CaCd_3$	c	126	$668_{HCl\ (a)}$	(197)
$CaBr_2.Hg_2Br_2$	4400	960	mix.	(1012)
$CaBr_2.2Hg_2Br_2$	8400	1197	mix.	(1012)
$Ca(CN)_2.Hg(CN)_2$	900	33.0	mix.	(1009)
$Ca(CN)_2.2Hg(CN)_2$	900	−133	mix.	1009
$CaCl_2.2Hg(CN)_2$	1000	330	mix.	(1009)
$CaCl_2.2Hg(CN)_2.6H_2O$	c	2108	-61.1^{18}	(1009)
$CaBr_2.2Hg(CN)_2$	1000	242	mix.	(1009)
$CaBr_2.2Hg(CN)_2.7H_2O$	c	2328	-82.9^{22}	(1009)
$CaI_2.2Hg(CN)_2$	1000	132	mix.	(1009)
$CaI_2.2Hg(CN)_2.4H_2O$	c	1943	−94	(1009)
$Ca[Ag(CN)_2]_2$	500	31	$Ca(CN)_2 + AgCN$	1011
$CaAgC_2N_2$	1000	287	$Ca(CN)_2 + AgCN$	(1011)
$Ca_2Fe(CN)_6$	aq.	378	N	555
$Ca_2Fe(CN)_6.12H_2O$	c	4081	-191^{0}	555
$Ca_2H_2Fe(CN)_6$	aq.	−34	N	555
$CaO.3_2O_3$	c	1986	94_{HCl}	462
$CaO.2B_2O_3$	c	3145	87_{HCl}	
$3CaO.2B_2O_3$	c	2646	21.6_{HCl}	
$2CaO.3B_2O_3$	c	3398	348.3_{HCl}	
$CaAl_2$	c	223	$1900_{HCl\ (a)}$	197
$CaO.Al_2O_3$	gla.	2300	$CaCO_3 + Al_2O_3$	275, 276)
$3CaO.Al_2O_3$	gla.	2900	$CaCO_3 + Al_2O_3$	(275, 276)
$3CaO.Al_2O_3$	gla.	3500	$CaCO_3 + Al_2O_3$	275, 276)
$3CaCl_2.4AlCl_3$	c	3264	1452	32)
$CaO.4SiO_2$ — wollastonite	c	3276	$1197_{HF\ (a\ \%)}$	(749)
$3CaO.Al_2O_3.2SiO_2$	c	5220	$CaCO_3 + Al_2O_3 + SiO_2$	276)
$CaMg_2$	c	1780	$338_{HCl\ (a)}$	193, 881)
$CaCl_2.MgCl_2.2H_2O$	c	2654	93.7	522
$MgCO_3.CaCO_{3\ dolomite}$	c	2589	132.4_{HCl}	24, 701)

Formula	State	Q, kj	Method	Lit.
Strontium[a]				
Sr	c	0	Def.	
Sr	aq.	345	$SrCl_2$	
SrO	c	589	125.5^{15}_{1100}	(67, 400, 401, 404, 976)
SrO_2	c	641	$93.0^{15}_{HCl\ (300}$	(385)
Sr_2O	c	643	782^{25}_{HCl}	46)
SrH_2	c	176	$368^{7}_{HCl\ (300)}$	(480)
$Sr(OH)_2$	c	957	43.2^{15}_{1100}; &	(67, 404, 976)
	aq.	1001	−HCl	97, 385, 976)
$Sr(OH)_2.H_2O$	c	1264	22.0^{15}_{1100}	(385)
$Sr(OH)_2.8H_2O$	c	3350	-59.7^{15}_{1100}	(67, 976, 434)
$SrO_2.9H_2O$	c	3301	$7.3^{25}_{HCl\ 300}$	(385)
SrF_2	ppt.	1209	$AgF + SrCl_2$; &	(464, 793)
SrCl	c	446	$264^{15}_{HCl\ (300}$	(46)
$SrCl_2$	c	828.0	46.7^{25}_{400}	32, 46, 157.5, 360.5; 621, 810, 976)
(see also p. 161)				
	2000	875.22	dil.	(324, 325, 653, 827)
	1000	875.12	dil.	
	500	874.78	dil.	
	200	874.7	Sr + HCl; &	430, 434, 976)
	100	874.61	dil.	
	50	874.57	dil.	
$SrCl_2.2H_2O$	c	1468.4	8.7^{25}_{400}	(900)
$SrCl_2.4H_2O$	c	2081.6	-12.1^{25}_{400}	13,* 429,* 810, 976)
$SrCl_2.6H_2O$	c	2623.2	-31.4^{18}_{400}	(55, 157.5, 360.5, 976)
$SrCl_2.SrO.H_2O$	c	1828	$164.5^{22}_{HCl\ (300}$	(11)
$SrCl_2.SrO.9H_2O$	c	4211	$70.0^{22}_{HCl\ (300}$	(11)
$SrBr_2$	c	716	67^{18}_{400}	(360.5, 966, 976)
	aq.	784	ions	
$SrBr_2.H_2O$	c	1029	41^{18}_{400}	(976)
$SrBr_2.2H_2O$	c	1330	26^{18}_{400}	(976)
$SrBr_2.4H_2O$	c	1928	0^{18}_{400}	(976)
$SrBr_2.6H_2O$	c	2528	-27.0^{18}_{400}	(360.5, 976)
$SrBr_2.SrO.3H_2O$	c	2313	161_{HBr}	(966)
$SrBr_2.SrO.9H_2O$	c	4102	68.8^{25}_{HBr}	(966)
SrI_2	c	570	85.6^{12}	(966)
	aq.	656	ions	
$SrI_2.7H_2O$	c	2678	-18.7^{25}	(966)
SrS	c	473	143_{HCl}	397)
	aq.	503	N; &	(976)
$SrSO_4$	c	1428	O; &	34, 976)
	aq.	1428	N; &	55, 279, 976)
SrS_2O_3	aq.	1096	ions	978)
$SrS_2O_6.4H_2O$	c	2876	-38.7^{18}_{400}	(976)
$Sr(HS)_2$	aq.	577	N	976)
$SrI_2.2SO_2$	c	1129	dissoc.*	342*)
$SrI_2.4SO_2$	c	1912	dissoc.*	342*)
SrSe	c	377	14_{HCl}	350)
	aq.	427	N	(350)
SrN_6	c	−205	dissoc.	1113)
Sr_3N_2	c	386	$1513.5_{HCl\ (300)}$	(480)
$Sr(NO_2)_2$	aq.	528	N; &	56)
$Sr(NO_2)_2.5H_2O$	c	1984	26.5_{HCl}	56)
$Sr(NO_3)_2$	c	981	-19.1^{5}_{400}	55, 360.5; 810,* 976)
(see also p. 162)				
	1000	961.8	dil.	
	400	962.3	ions; &	55
	200	963.2	dil.	827,* 976)
	100	963.8	dil.	
	50	967.9	dil.	
	20	973.2	dil.	
$Sr(NO_3)_2.4H_2O$	c	2158	-51.3^{5}_{400}	55, 360.5, 810, 976)
$Sr(NH_2)_2$	c	346	$404_{HCl\ (a)}$	450
$Sr(NH_2)_4$	c	516	dissoc.*	1214*)

[a] $SrCl_2 + HCl$, partial heat content of HCl (301†).

Formula	State	Q, kj	Method	Lit.
Strontium.—(*Continued*)				
$SrCl_2.NH_3$	c	915	dissoc.*	(528*)
$SrCl_2.8NH_3$	c	1571	dissoc.*	(528*)
$SrBr_2.NH_3$	c	830	dissoc.*	(528*)
$SrBr_2.2NH_3$	c	929	dissoc.*	(528*)
$SrBr_2.8NH_3$	c	1479	dissoc.*	(528*)
$SrI_2.NH_3$	c	692	dissoc.*	(528*)
$SrI_2.2NH_3$	c	803	dissoc.*	(528*)
$SrI_2.6NH_3$	c	1197	dissoc.*	(528*)
$SrI_2.8NH_3$	c	1381	dissoc.*	(528*)
$SrSO_4.(NH_4)_2SO_4$	c	2594	-13.4_{1500}	(30)
$Sr_3(PO_4)_2$	ppt.	410c	N; &	(86, 129, 569)
$SrHPO_4$ (?)	ppt.	182c	N	(86, 129, 569)
$SrH_4(PO_4)_2$ (?)	ppt.	312c	N	(86, 129, 569)
$Sr_3(AsO_4)_2$	ppt.	333c	N	(201)
$SrHAsO_4$	ppt.	143c	N	(201)
$SrH_4(AsO_4)_2$ (?)	ppt.	234c	N	(201)
$SrCO_3$	ppt.	1219	$SrCl_2 + Na_2CO_3$; &	(55, 58, 565,* 976)
$SrC_2O_4.2\frac{1}{2}H_2O$	c	2107	N	(56)
$Sr(CHO_2)_2$	c	1370	2.6^{15}_{500}	(55)
	aq.	1373	N; &	(55, 976)
$Sr(CHO_2)_2.2H_2O$	c	1967	-22.8^{11}_{500}	(55, 976)
$Sr(C_2H_3O_2)_2$	c	1505	23.3^{12}_{200}	(55, 976)
	aq.	1529	N; &	(55, 976)
$Sr(C_2H_3O_2)_2.\frac{1}{2}H_2O$	c	1650	22.0^{12}_{220}	(55, 976)
$Sr(CN)_2$	aq.	254	N	(555,c 976)
$Sr(CN)_2.4H_2O$	c	1416	-17.4^{8}_{200}	(555c)
$SrSiO_3$	gls.	152c	$SrCO_3 + SiO_2$	(275)
$SrHg_{(\infty)}$	liq.	249	NaHg + $SrCl_2$ aq.	(928*)
$SrBr_2.HgBr_2$	4400	951	mix.	(1012)
$SrBr_2.2HgBr_2$	8400	1109	mix.	(1012)
$2SrBr_2.HgBr_2$	4800	1744	mix.	(1012)
$Sr(CN)_2.Hg(CN)_2$	600	34	mix.	(1009)
$Sr(CN)_2.2Hg(CN)_2$	900	−231	mix.	(1009)
$SrCl_2.2Hg(CN)_2$	1000	331	mix.	(1009)
$SrCl_2.2Hg(CN)_2.6H_2O$	c	2115	-66^{15}	(1009)
$SrBr_2.2Hg(CN)_2$	1000	244	mix.	(1009)
$SrBr_2.2Hg(CN)_2.6H_2O$	c	2039	-78^{15}	(1009)
$SrI_2.2Hg(CN)_2$	1000	134	mix.	(1009)
$SrI_2.2Hg(CN)_2.7H_2O$	c	2228	-91^{15}	(1009)
$Sr(Ag(CN)_2)_2$	500	30	$Sr(CN)_2 +$ AgCN	(1011)
$SrAg(CN)_3$	600	145	$Sr(CN)_2 +$ AgCN	(1011)
$Sr_3(FeCO(CN)_5)_2$	c	1115	167^{13}_{5500}	(747, 748)
	aq.	1282	N; &	(747, 748)
$Sr_3(FeCO(CN)_5)_2.4H_2O$	c	2291	$+136^{13}_{5700}$	(747, 748)
$SrNi(CN)_4$	220	201	$Sr(CN)_2 +$ $Ni(CN)_2$	(1010)
$3SrCl_2.4AlCl_3$	c	5344	1375.9^{21}_{1600}	(32)
Barium[a]				
Ba	c	0	Def.	
Ba^{++}	aq.	537	$BaCl_2$	
BaO	c	557	150.0^{15}_{600}; &	(67, 404, 976)
	aq.	708	$= Ba(OH)_2$	
BaO_2	c	635	92^{12}_{HCl}; &	(92, 519,* 616*)
$BaO_2.H_2O$	c	932	80_{HCl}	(92)
$BaO_2.10H_2O$	c	3576	11.4_{HCl}	(92, 384)
Ba_2O	c	623	$738^{15}_{HCl\ (200)}$	(46)
BaH_2	c	171	367^{7}_{HCl}; &	(477)
$Ba(OH)_2$	c	945.2	47.7^{15}_{660}	(67, 404, 976)
	400	993.9	N, $BaCl_2$; &	(9, 67, 476, 940, 976)
$Ba(OH)_2.H_2O$	c	1250	29.5^{15}_{660}	(404)
$Ba(OH)_2.8H_2O$	c	3344	-60.7^{15}_{660}	(67, 404, 921, 976)
$BaO_2.H_2O_2$	c	865	49^{12}_{HCl}	(92, 377)
BaF_2	ppt.	1204	N; &	(464, 793)
	aq.	1192 ?)	−2; &	(793)

[a] $Ba(NO_2)_2.Pb(NO_2)_2$, solid solutions (959). $Ba_2P_2O_6$ (?) heat of ppt. (568). $BaCl_2.HCl$, heat content of HCl (501).

Formula	State	Q, kj	Method	Lit.
Barium.—(*Continued*)				
BaCl	c	466	$236^{15}_{HCl\ (200)}$	(46)
$BaCl_2$	c	859.3	8.7^{18}_{400}	(32, 53, 157.5,c 359, 590, 623,c 910, 976)
(*see also* p. 161, 162)				
	2000	868.58	dil.	(653, 827,c 930c†)
	1000	868.29	dil.	
	400	867.76	dil.	
	200	867.55	Ba + HCl	(477, 480, 976)
	100	867.43	dil.	
	50	867.58	dil.	
$BaCl_2.2H_2O$	c	1460.9	-20.6^{18}_{400}	(53, 360.5, 429,c 910, 976)
$Ba(ClO)_2$	aq.	757	$Cl_2 + Ba(OH)_2$	(69)
$Ba(ClO_2)_2$	c	660	dissoc.	(252)
$Ba(ClO_3)_2$	c	728	-28^{10}_{600}	(55)
	200	700	$+SO_2$; &	(77, 976)
$Ba(ClO_3)_2.H_2O$	c	1033	-47.0^{18}_{600}	(55, 976)
$Ba(ClO_4)_2$	c	880	-7^{10}_{800}	(55, 976)
	800	872	N; &	(104, 976)
$Ba(ClO_4)_2.3H_2O$	c	1770	-39_{1000}	(55)
$BaCl_2.BaO.3H_2O$	c	2421	+HCl	(11)
$BaCl_2.BaO.5H_2O$	c	3045	77^{12}_{HCl}	(11, 964)
$BaCl_2.BaO.8H_2O$	c	3899	HCl	(11)
$BaBr_2$	c	755	20.8^{18}_{400}	(976, 1009)
	400	776	ions	
$BaBr_2.2H_2O$	c	1366	-17.5^{18}_{400}	(976)
$Ba(BrO)_2$	aq.	73c	$Ba(OH)_2 +$ Br	(81)
$BaBr_2.BaO.2H_2O$	c	2031	141_{HBr}	(965)
$BaBr_2.BaO.5H_2O$	c	2949	83^{20}_{HBr}	(965)
BaI_2	c	606	43.1^{16}	(965)
	aq.	649	ions	(965)
$BaI_2.7H_2O$	c	2680	-28.7^{18}_{500}	(976)
$Ba(IO_3)_2$	c	1026	$-19^{18}_{K_2SO_4}$	(278)
	aq.	990	ions	
$Ba(IO_3)_2.H_2O$	c	1324	$+Na_2SO_4$	(278)
$BaI_2.BaO.2H_2O$	c	1905	139^{20}_{HI}	(965)
$BaI_2.BaO.9H_2O$	c	3998	49.2^{20}_{HI}	(965)
BaS	c	465	114^{10}_{HCl}	(897)
	aq.	496	N	(60, 976)
$BaSO_3$	ppt.	117c	N	(374)
$BaSO_4$	ppt.	1445	N; &	(58, 748,c 976)
	aq.	1420	ions; &	(695†)
BaS_2O_6	aq.	1686	$+H_2SO_4$	(976)
$BaS_2O_6.2H_2O$	c	2287	-29.0^{18}_{400}	(976)
BaS_2O_8	aq.	1855	$+H_2SO_4$	(135)
$BaS_2O_8.4H_2O$	c	3049	-49^{12}_{1700}	(135)
$Ba(HS)_2$	aq.	570	N	(976)
$Ba(HSO_3)_2$	aq.	1787	N	(374)
$BaSO_4.H_2SO_4$	c	2260	59.6^{18}_{2260}	(1017)
$BaSO_4.2H_2SO_4.H_2O$	c	3380	101.0^{16}_{2260}	(1017)
$BaI_2.2SO_2$	c	1281	dissoc.*	(342*)
$BaI_2.4SO_2$	c	1943	dissoc.*	(342*)
BaSe	c	369	142_{HCl}	(350)
$BaSeO_4$	ppt.	1163	$BaCl_2 + H_2SeO_4$	(696)
BaN_6	c	82	-33_{650}	(164)
	aq.	49	$+H_2SO_4$	(164)
Ba_3N_2	c	380	$1498^{8}_{HCl\ (500)}$	(476, 480)
$Ba(NO_2)_2$	c	777	-23.8^{12}_{800}	(71)
	aq.	753	$+H_2SO_4$; &	(71)
$Ba(NO_2)_2.H_2O$	c	1075	-36^{12}_{800}	(71)
$Ba(NO_3)_2$	c	997.2	-39.6^{18}_{400}	(55, 934†)
(*see also* p. 162)	1600	956.0	dil.	(198, 827,c 934†)
	800	956.7	N; &	(55, 58, 976)
	400	957.6	dil.	
	200	960.2	dil.	

Formula	State	Q, kj	Method	Lit.
Barium.—(*Continued*)				
$BaNH$	c	224	$446^{8}_{HCl\ (200)}$	(480)
$Ba(NH_2)_2$	c	330	$473.3^{8}_{HCl\ (200)}$	(476, 480)
$Ba(NH_3)_6$	c	313	dissoc.*	(191)
$BaCl_2.8NH_3$	c	1485	dissoc.*	(531*)
$BaBr_2.NH_3$	c	851	dissoc.*	(531*)
$BaBr_2.2NH_3$	c	941	dissoc.*	(531*)
$BaBr_2.4NH_3$	c	1118	dissoc.*	(531*)
$BaBr_2.8NH_3$	c	1468	dissoc.*	(531*)
$BaI_2.2NH_3$	c	809	dissoc.*	(531*)
$BaI_2.4NH_3$	c	996	dissoc.*	(531*)
$BaI_2.6NH_3$	c	1180	dissoc.*	(531*)
$BaI_2.8NH_3$	c	1361	dissoc.*	(531*)
$BaI_2.9NH_3$	c	1449	dissoc.*	(531*)
$BaI_2.10NH_3$	c	1527	dissoc.*	(531*)
$Ba_3(PO_4)_2$	coll.	4080	N; &	(86, 129)
	c	4150	N	(86, 129)
$BaHPO_4$ (?)	ppt.	1810	N	(86, 129, 568)
$Ba(H_2PO_2)_2$	aq.	1733	$+H_2SO_4$	(976)
$Ba(H_2PO_2)_2.H_2O$	c	2018	1.2^{18}_{400}	(976)
$BaH_4(PO_4)_2$ (?)	ppt.	3010	N	(86)
$Ba_3(AsO_4)_2$	ppt.	3422	N	(202)
$BaHAsO_3$	ppt.	1194	N	(976)
$BaHAsO_4$	ppt.	1435	N	(202)
$Ba(H_2AsO_3)_2$	ppt.	1961	N	(976)
$Ba(H_2AsO_4)_2$	ppt.	2334	N	(202)
$BaCO_3$	ppt.	1217.2	$Na_2CO_3 + BaCl_2$	(55, 58, 565,* 976)
$BaCO_{3(II)}$ (witherite)	c			
$BaCO_{3(I)}$	c		$Tr.; 7.3^{800}_{(II)}$	(608)
$BaC_2O_4.H_2O$	ppt.	1663	$(NH_4)_2C_2O_4 + BaCl_2$	(56)
$Ba(HCO_2)_2$	c	1376	-10.2^{8}_{500}	(53)
	aq.	1366	ions; &	(73)
$Ba(C_2H_3O_2)_2$	c	1500	22^{11}_{600}	(55)
	aq.	1522	$+H_2SO_4$	(53, 55, 976)
$Ba(C_2H_3O_2)_2.3H_2O$	c	2383	-3.4	(55)
$Ba(C_2H_5O)_2$	c	911	82.7^{19}	(373)
$3BaO.4CH_3OH$	c	3035	469.3_{HCl}	(380)
$3BaO.4C_2H_5OH$	c	3063	205^{16}_{8000}	(380)
$Ba(C_2H_5SO_4)_2$	aq.	2354	$+H_2SO_4$	(976)
$Ba(C_2H_5SO_4)_2.2H_2O$	c	2905	20.8^{18}_{800}	(976)
$Ba(CN)_2$	c	239	7.4^{9}	(555)
	aq.	247	N; &	(555)
$Ba(CN)_2.H_2O$	c	544	-9^{6}	(555)
$Ba(CN)_2.2H_2O$	c	838	-20^{7}	(555)
$Ba(CNO)_2$	c	891	-62_{1500}	(626)
	aq.	829	$+HNO_2$; &	(626)
$BaHC_6N_5O_8.1\frac{1}{2}H_2O$	c	1588	$96_{H_2SO_4}$	(626)
$Ba(H_2C_6N_5O_8)_2.2H_2O$	c	2470	$37.3_{H_2SO_4}$	(626)
$Ba(SbOC_4H_4O_6)_2$	c	3512	48_{HCl}; &	(468)
$Ba(SbOC_4H_4O_6)_2.2H_2O$	c	4111	18_{HCl}; &	(468)
$BaSiO_3$	gls.	1490	$BaCO_3 + SiO_2$	(275)
$BaSiF_6$	c	2835	N; &*	(1090*)
$BaBr_2.HgBr_2$	4400	945	mix.	(1012)
$BaBr_2.2HgBr_2$	8400	1101	mix.	(1012)
$2BaBr_2.HgBr_2$	4800	1731	mix.	(1012)
$Ba(CN)_2.Hg(CN)_2$	600	27	mix.	(1009)
$Ba(CN)_2.2Hg(CN)_2$	900	− 239	mix.	(1009)
$BaCl_2.2Hg(CN)_2$	1000	325	mix.	(1009)
$BaCl_2.2Hg(CN)_2.5H_2O$	c	1827	-72^{15}	(1009)
$BaBr_2.2Hg(CN)_2$	1000	237	mix.	(1009)
$BaBr_2.2Hg(CN)_2.6H_2O$	c	2041	-88^{15}	(1009)
$BaI_2.2Hg(CN)_2$	900	126	mix.	(1009)
$BaI_2.2Hg(CN)_2.4H_2O$	c	1363	-92^{15}	(1009)
$BaAg(CN)_3$	1200	136	$Ba(CN)_2 + AgCN$	(1008)
$Ba(Ag(CN)_2)_2$	500	20	$Ba(CN)_2 + AgCN$	(1008)
$BaPtCl_6$	c	1192	$38^{19*}_{5\ 000}$	(453*)
	aq.	1230	ions*	(453*)
$BaPtCl_6.6H_2O$	c	2952	-4.4	(453*)
$Ba_2Fe(CN)_6$	aq.	565	N	(555)
$Ba_2Fe(CN)_6.6H_2O$	c	2329	-48^{14}	(555)
$BaH_2Fe(CN)_6$	aq.	32	N	(555)
$Ba_3(FeCO(CN)_5)_2$	c	1186	$71^{15}_{10\ 000}$	(747, 748)
	aq.	1256	N	(747, 748)
$Ba_3(FeCO(CN)_5)_2.11H_2O$	c	4433	$-29^{18}_{12\ 000}$	(747, 748)
$Ba(CN)_2.Ni(CN)_2$	aq.	200	mix.	(1010)
$BaCrO_4$	ppt.	1398	$BaCl_2 + K_2CrO_4$	(279)
$BaCl_2.2AlCl_3$	c	2273	642	(32)
$3BaCl_2.4AlCl_3$	c	5404	1295	(32)
Lithium[a]				
Li	c	0	Def.	
Li^+		278.1		
Li_2O	c	593	131^{15}_{220}; &	(40, 400°)
$4Li_2O.3H_2O$	c	3686	67.1^{15}_{250}	(403)
Li_2O_2	c	627	30.1^{20}; &	(388)
	aq.	657	+HCl	(388)
LiH	c	90	131^{18}_{2000}	(473, 529,* 718)
$LiOH$	c	487	18.7^{24}_{110}	(397, 403)
	∞	506.4	dil.	
	2000	506.89	$Li + H_2O$; &	(473, 718,° 976, 1074)
	400	506.18	dil.	(400, 401,
	200	505.97	dil.	867,° 976)
	100	505.71	dil.	
	50	505.41	dil.	
	25	504.9	dil.	
$LiOH.H_2O$	c	789.2	3.0^{18}_{220}	(397, 403)
$LiOH.\frac{1}{2}H_2O$	c	536.5	4.3^{15}_{25}	(403)
$Li_2O_2.H_2O_2.3H_2O$	c	1710	19^{15}_{110}; &	(388)
LiF	c	609.1	-4.3^{15}_{110}	(410)
	aq.	604.7	N	(793)
$LiHF_2$	400	920.7	LiF + HF	(793)
$LiCl$	c	407.7	35.6^{18}_{200}	(45, 493, 604, 757, 811)
	∞	443.77	dil.	
	400	443.44	dil.	(324,† 604,° 625, 867,° 1003†)
	200	443.27	N	(742, 868, 976)
	100	442.98	dil.	(604)
	50	442.61	dil.	
	25	442.06	dil.	
	10	440.05	dil.	
	5	435.49	dil.	
	3	427.79	dil.	
$LiCl.H_2O$	c	712.2	17.2	(217, 533*)
$LiCl.2H_2O$	c	1011.5	4.1	(217, 533*)
$LiCl.3H_2O$	c	1310.3	dissoc.*	(533*)
$LiBr$	c	350.4	47.1^{14}_{350}	(206, 533*)
	200	397.84	N	(868)
$LiBr.H_2O$	c	665	dissoc.*	(533*)
$LiBr.2H_2O$	c	969	-5.0; &	(205, 533)
$LiBr.3H_2O$	c	1270	dissoc.*	(533*)
LiI	c	272.0	61.8^{18}_{200}	(45, 206)
	200	333.79	N	(533, 868)
$LiI.\frac{1}{2}H_2O$	c	435.5	dissoc.*	(532*)
$LiI.H_2O$	c	595	dissoc.*	(352*)
$LiI.2H_2O$	c	906	dissoc.*	(532*)
$LiI.3H_2O$	c	1216	dissoc.*	(532*)
$Li_2SO_{4(I)}$	c		$Tr.; 2.85^{5.66}_{(II)}$	(1091)
$Li_2SO_{4(II)}$	c	1414	26.7	(810, 976)
	800	1440	N; &	(976, 1074)
$Li_2SO_4.H_2O$	c	1712	14.3^{18}_{400}	(810,° 976)
$LiI.SO_3$	c	603	dissoc.*	(342*)
$LiI.2SO_3$	c	932	dissoc.*	(342*)
Li_2Se	c	399	44.6^{20}	(350)
	aq.	444	N	(350)
$Li_2Se.9H_2O$	c	3070	-51_{3000}	(350)
Li_3N	c	192	549	(474)
$LiNO_3$	c	484.7	1.8^{21}_{400}	(493, 811, 976)
	∞	486.59	dil.	(867°)
	400	486.46	dil.	

[a] LiCl + HCl, partial heat content of HCl (500).

Formula	State	Q, kj	Method	Lit.
Lithium.—(*Continued*)				
$LiNO_3$.—(*Continued*)	200	486.36	N	(868°)
	100	486.25	dil.	
	50	486.15	dil.	
	25	486.05	dil.	
	3	481.3	analogy	
$LiNO_3.3H_2O$	c	1374.0	→liq.	(731)
$LiNH_2$	c	179	$232^{15}_{HCl(200)}$	(480
$Li(NH_3)_4$	liq.	328	dissoc.*	(46*)
Li_2NH	c	217	472^{15}_{HCl}	(480)
$LiCl.NH_3$	c	502.3	22.4^{15}_{380}; &	(187,* 220*)
$LiCl.2NH_3$	c	594.8	11.2^{18}_{440}; &	(187,* 220*)
$LiCl.3NH_3$	c	685.8	1.5^{18}_{550}; &	(187,* 220*)
$LiCl.4NH_3$	c	767.6	1.0^{11}_{660}; &	(187,* 220*)
$LiCl.5NH_3$	c	846	dissoc.*	(187)
$LiBr.NH_3$	c	450	28.7^{15}_{320}; &	(187, 220*)
$LiBr.2NH_3$	c	548	12.6^{8}_{440}; &	(187, 220*)
$LiBr.3NH_3$	c	640	1.2^{10}_{550}; &	(187, 220*)
$LiBr.4NH_3$	c	729	-6.5^{8}_{600}; &	(187, 220*)
$LiBr.5NH_3$	c	809	dissoc.*	(187*)
$LiBr.6\frac{1}{2}NH_3$	c	921	dissoc.*	(187*)
$LiI.NH_3$	c	385	dissoc.*	(187*)
$LiI.2NH_3$	c	489	dissoc.*	(187*)
$LiI.3NH_3$	c	585	dissoc.*	(187*)
$LiI.4NH_3$	c	680	dissoc.*	(187*)
$LiI.5NH_3$	c	759	dissoc.*	(187*)
$LiI.5\frac{1}{2}NH_3$	c	797	dissoc.*	(187*)
$LiI.7NH_3$	c	910	dissoc.*	(187*)
Li_2C_2	c	57	155^{17}	(475)
Li_2CO_3	c	1217	12.8^{15}_{220}	(402, 565*)
	aq.	1230	N; &	(402, 742)
$LiHCO_3$	500	972	+HCl aq.	(742)
$LiCH_3O_{(CH_3OH)}$	CH_3OH	482	$Li + CH_3OH$	(376)
$LiC_2H_5O_{(C_2H_5OH)}$	C_2H_5OH	491	$Li + C_2H_5OH$	(376)
$LiCN$	200	131	N	(1007)
$LiCl.CH_3NH_2$	c	496	27.9_{200}	(221)
$LiCl.2CH_3NH_2$	c	577	28.0_{400}	(221)
$LiCl.3CH_3NH_2$	c	653	33.0_{500}	(221)
Li_2SiO_3	gls.	1560	$Li_2CO_3 + SiO_2$	(275)
	c	1820	gls.	(917)
Li_2SiF_6	c	2835.3	7.6_{800}	(1001)
	aq.	2842.9	$LiF + SiF_4$	(1001)
$LiCl.ThCl_4$	c	1822	262.2	(268)
$LiCl.ThCl_4.8H_2O$	c	4269	105.1	(268)
$2LiCl.ThCl_4$	c	2239	288.0	(268)
$LiHg$	c	84	$Li + Hg$	(1074)
$LiHg_2$	c	94	$+H_2SO_4$	(1074)
$LiHg_3$	c	105	$+H_2SO_4$	(1074)
$LiHg_{99}$	liq.	82.0	Li + Hg*	(639*)
$LiBr.HgBr_2$	4200	559	mix.	(1012)
$2LiBr.HgBr_2$	4400	962	mix.	(1012)
$4LiBr.HgBr_2$	4800	1765	mix.	(1012)
$LiCN.Hg(CN)_2$	400	− 112	mix.	(1009)
$2LiCN.Hg(CN)_2$	600	41	mix.	(1009)
$LiCl.Hg(CN)_2$	1000	172	mix.	(1009)
$LiBr.Hg(CN)_2$	1000	128	mix.	(1009)
$LiBr.Hg(CN)_2.3\frac{1}{2}H_2O$	c	1168	-38.3^{15}	(1009)
$LiI.Hg(CN)_2$	1000	73	mix.	(1009)
$LiI.Hg(CN)_2.3\frac{1}{2}H_2O$	c	1118	-43.3^{15}	(1009)
Sodium[a]				
Na	c	0	Def.	(438,* 489,* 491,* 875*)
	gas	− 105	→ c*	

[a] Heats of solution of melted salt mixtures:

	Fresh fused	Old fused	Lit.
$Na_2SO_4.MgSO_4$	71.6^{17}	69.8^{19}	(157.5)
$2NaCl.CaCl_2$	62.4^{10}	62.9^{14}	
$2NaCl.SrCl_2$	36.9^{12}	35.3^{14}	
$Na_2SO_4.SrSO_4$	2.8	5.4^{18}	
$2NaCl.BaCl_2$	− 3.9	3.4	
$Na_2SO_4.BaSO_4$	8.2^{14}	8.7^{17}	
$2Na_2SO_4.BaSO_4$	11.2^{18}	5.4^{18}	(777)
NaCl.LiI	-44.4_{200}		(45)

NaCl + HCl, partial heat content HCl (500).
$2NaCl.BaCl_2$, heat of dilution (930).

Formula	State	Q, kj	Method	Lit.
Sodium.—(*Continued*)				
Na^+	∞	240.8	NaCl; &	(39, 40, 283, 854°)
Na_2O	c	415	236	(383)
Na_2O_2	c	495.6	175.0_{HCl}; &	(383)
Na_2O (?)	c	425	409	(383)
NaH	c	55	109^{18}_{200}; &	(394, 579,* 726,* 996)
$NaOH_{(\beta)}$	c	426.5	43.1^{22}_{160}	(55,° 392, 976)
$NaOH_{(\alpha)}$	c		Tr.; $4.1^{299.6}_{(\beta)}$	(515)
(*see also* p. 161)	∞	468.88	dil.	(65, 408, 827,° 867,° 897, 976,° 1003†)
	500	468.90	dil.	
	400	468.92	dil.	
	200	468.98	dil.	
	100	469.14	$Na + H_2O$	(6, 359, 555, 854, 976)
	50	469.48	dil.	
	25	469.54	dil.	
	13.5	470.23	dil.	
	9	469.5	dil.	
	7	469.1	dil.	
	5	465.5	dil.	
	3	456.6	dil.	
$NaOH.\frac{1}{2}H_2O$	c	577	35^{22}_{160}	(392)
$NaOH.H_2O$	c	725	30.1^{22}_{180}	(65, 392)
$NaHO_2$	aq.	393	$+HNO_3$; &	(574)
NaF	c	570.4	-2^{12}_{400}	(464)
	aq.	567.9	N; &	(740, 976)
$NaHF_2$	c	909	-26^{12}_{400}	(464)
	400	883	NaF + HF	(976)
NaCl	c	411.64	-5.36^{18}_{200}	(45, 54, 157.5,° 241,† 295,° 623,° 777, 837,°† 909,° 934, 976, 1006,°† 1046°)
	gas	184	→ (c)	(366, 492)
	∞	406.28	dil.	(6,*† 22, 623, 653, 827,° 837,† 867,° 909, 934,† 938,† 976, 1070°)
	500	406.26	dil.	
	400	406.26	dil.	
	200	406.30	N; &	(6,* 50, 187, 330, 580,° 646,° 670, 671, 742,° 867,° 940, 976,° 1006°)
	100	406.50	dil.	
	50	406.99	dil.	
	25	407.86	dil.	
	10	409.2	dil.	
NaClO	800	349	N; &	(976)
$NaClO_2$	c	344.6	$+KNO_3$;* &	(55, 246*)
	aq.	322.5	N; &	(976)
$NaClO_4$	c	421	-15^{10}_{400}	(52, 55)
	aq.	407	ions	(104)
NaBr	c	361.3	-0.8^{18}_{200}	(55, 360.5, 976)
	200	360.54	N; &	(867°)
	100	361.0	dil.	(313,† 324†)
	14	363.3	dil.	
	6.8	365.1	dil.	
$NaBr.2H_2O$	c	953	-19.7^{18}_{300}	(55, 360.5, 976)
NaBrO	aq.	331	NaOH + Br	(81, 976)
NaI	c	290.7	5.9^{18}_{200}	(55, 360.5, 811, 976, 1009)
	200	296.59	N	(868°)
$NaI.2H_2O$	c	885.7	-16.8^{18}_{200}	(55, 360.5, 976)
Na_2S	c	376	65; &	(855, 897)
	400	440.3	N; &	(50, 60, 897, 976)
	200	440.4	dil.	(897)
	100	440.8	dil.	
	50	441.2	dil.	
	20	442.3	dil.	
	10	443.7	dil.	

Formula	State	Q, kj	Method	Lit.
Sodium.—(*Continued*)				
$Na_2S.4\frac{1}{2}H_2O$	c	1749	-21^{17}_{1000}	(897)
$Na_2S.5H_2O$	c	1899	-28^{13}_{1000}	(897)
$Na_2S.9H_2O$	c	3086	-70^{13}_{1000}	(897)
Na_2S_2	aq.	442	+HI	(897)
Na_2S_3	aq.	449	+HI	(897)
Na_2S_4	c	414	41^{17}_{1200}	(897)
	aq.	455	+HI	(897)
Na_2SO_3	c	1085	10^{10}	(375)
	800	1096	N	(375, 646,° 976)
$Na_2SO_3.7H_2O$	c	3145	-46^{10}_{600}	(375)
Na_2SO_4	c	1365.6	2.3^{18}_{400}	(53, 157.5,°
	∞	1367.1	extrap.	246,* 360.5,
	800	1367.5	dil.	458, 707,
				804,° 807,
				891, 976,
				979, 1006°)
	400	1367.9	N; &	(50, 53, 671,
				745, 843,
				976°)
	200	1369.0	dil.	(976,° 1006°)
	100	1370.9	dil.	
	50	1373.7	dil.	
$Na_2SO_4.10H_2O$	c	4309.0	-79.1^{18}_{400}	(281, 355,
				360.5, 458,
				807,° 976,
				978,° 979,
				1100)
$Na_2S_2O_3$	c	1064	7^{15}_{440}	(117, 369)
	aq.	1071	+HClO	(132, 976)
$Na_2S_2O_3.5H_2O_{(\alpha)}$	c	2550	-47.6^{18}_{400}	(121, 976)
$Na_2S_2O_3.5H_2O_{(\beta)}$	c	2546.1	Tr.; $3.87^{18}_{(\alpha)}$	(737°)
$Na_2S_2O_4$	aq.	1146	$+O_2$	(78)
$Na_2S_2O_5$	c	1452	-22^{10}_{500}	(375)
	1200	1430	N	(375, 976)
$Na_2S_2O_6$	c	1653	-23.8^{19}_{400}	(976)
	400	1629	ions	(976)
$Na_2S_2O_6.2H_2O$	c	2250	-48.8^{17}_{400}	(976)
$Na_2S_3O_6$	aq.	1575	$+Br_2$; &	(131)
$Na_2S_3O_6.3H_2O$	c	2475	-42^{11}_{1000}	(131)
$Na_2S_4O_6$	aq.	1578	$Na_2S_2O_3$ + I; &	(131, 976)
$Na_2S_4O_6.2H_2O$	c	2191	-41^{10}_{600}	(131)
$NaHS_2$	c	239	18^{16}_{600}	(897)
	400	257.2	dil.	
	200	257.3	N; &	(897, 976)
	100	257.6	dil.	(897)
	50	258.0	dil.	
	20	259.7	dil.	
	10	265.7	dil.	
$NaHS.2H_2O$	c	836	-6.4^{18}_{400}	(897)
$NaHSO_3$	600	858	$=Na_2S_2O_5$	
$NaHSO_4$	c	1109.8	5.0^{17}_{200}	(50, 976)
	800	1116.8	dil.	(976)
	400	1115.9	dil.	
	200	1114.8	N; &	(843, 976)
	100	1114.2	dil.	
	50	1114.0	dil.	
	20	1113.6	dil.	
	10	1111.8	dil.	
$NaHSO_4.H_2O$	c	1402	−1.2	(355)
$NaI.2SO_2$	c	955	dissoc.*	(342,* 425*)
$NaI.4SO_2$	c	1615	dissoc.*	(342,* 425*)
Na_2Se	c	291	77.8^{14}_{200}	(350)
	aq.	369	N	(350)
$Na_2Se.4\frac{1}{2}H_2O$	c	1690	−33	(350)
$Na_2Se.9H_2O$	c	2989	−44	(350)
$Na_2Se.16H_2O$	c	4980	-92^{14}_{3000}	(350)
Na_2SeO_3	800	997	N	(976)
Na_2SeO_4	c	1094	$Se + Na_2O_2$	(711)
	400	1094	N; &	(696, 976)
$NaHSe$	aq.	187	N	(350)

Formula	State	Q, kj	Method	Lit.
Sodium.—(*Continued*)				
$NaHSeO_3$	600	763	N	(976)
$NaHSeO_4$	aq.	844.7	Na_2SeO_4 + H_2SeO_4; &	(696, 976)
Na_2TeO_4	c	1283	$Te + Na_2O_2$	(711)
	aq.	1205	N	(696)
$NaNO_2$	c	362	-14.7_{250}	(686, 954)
	aq.	348	+HCl + $CO(NH_2)_2$	(686, 954)
$NaNO_3$	c	470.6	-21.0^{17}_{200}	(53, 246,*
(*see also* p. 162)	∞	449.18	dil.	493, 909,
	400	449.32	dil.	934,† 976,
				978,° 1006,°
				1046°)
	200	449.66	N	(52, 671, 867,°
				976)
	100	450.34	dil.	(198, 312,†
	50	451.44	dil.	827,° 867,
	25	453.27	dil.	890,† 934,†
	6	458.0	dil.	935)
$Na_2(NO)_2$	aq.	466	$Sr(NO)_2.5H_2O$ + $NaSO_4$; &	(133)
$NaNH_2$	c	135	130^{21}	(382)
$NaNH_3$	c	67.6	dissoc.	(559)
$NaCl.5NH_3$	c	808	dissoc.*	(187*)
$NaBr.5\frac{1}{2}NH_3$	c	1045	dissoc.*	(187*)
$NaI.4\frac{1}{2}NH_3$	c	674	dissoc.*	(187*)
$NaI.6NH_3$	c	790	dissoc.*	(187*)
$Na_2SO_4.(NH_4)_2SO_4.H_2O$	c	3719	-54.4^{16}	(688)
$NaPO_3$	c	1209	16.6^{15}	(447)
	600	1225	N	(447)
Na_3PO_4 (?)	c	1871	$P + Na_2O_2$	(710)
Na_3PO_4	900	1972.4	N	(160, 161, 976)
$Na_3PO_4.12H_2O$	c	5467	-61^{18}_{600}	(569)
$Na_4P_2O_6$	aq.	1042 + $H_4P_2O_6$	N	(567)
$Na_4P_2O_7$	c	3160	49.6^{18}_{800}	(976)
	1600	3210	N	(447, 976)
$Na_4P_2O_7.10H_2O$	c	6120	-48.8^{18}_{800}	(976)
NaH_2PO_2	aq.	837	N	(976)
NaH_2PO_3	c	1199	3.1^{15}_{500}	(8)
	600	1202	N	(8, 976)
$NaH_2PO_3.2\frac{1}{2}H_2O$	c	1940	-22^{15}_{500}	(8)
	300	1525.9	N	(160, 161, 976)
$NaH_3P_2O_6$	aq.	246 + $H_4P_2O_6$	N	(567)
$NaH_3P_2O_7$	c	2498	2.8^{15}	(447)
	1200	2501	N; &	(447, 976)
$NaH_2PO_4.H_3PO_4$	c	2803	4.7^{15}	(446, 447)
Na_2HPO_3	c	1403.8	38.3^{14}_{500}	(8)
	aq.	1442	N	(8)
$Na_2HPO_3.5H_2O$	c	2892	-19.2^{15}_{500}	(8)
Na_2HPO_4	c	1736.7	23.6^{18}_{400}	(801, 802, 976)
	600	1760.3	N	(160, 161, 976)
$Na_2HPO_4.2H_2O$	c	2334.3	-1.6^{18}_{400}	(976)
$Na_2HPO_4.7H_2O$	c	3812	-48^{18}_{400}; &	(430,* 749,* 801, 802, 976)
$Na_2HPO_4.12H_2O$	c	5289.9	-95.5^{18}_{400}	(216, 749, 801, 802, 976)
$Na_2H_2P_2O_5$	c	2088	1^{13}_{1100}	(8)
	aq.	2090	N	(8, 359)
$Na_2H_2P_2O_6$	aq.	492 + $H_4P_2O_6$	N	(567)
$Na_2H_2P_2O_7$	c	2753	−9.5	(447)
	1200	2744	N	(447, 976)
$Na_2H_2P_2O_7.6H_2O$	c	4519	−58.2	(447)
$Na_3HP_2O_6$	aq.	728 + $H_4P_2O_6$	N	(567)
$Na_3HP_2O_7$	c	2954	28.3	(447)

Formula	State	Q, kj	Method	Lit.
Sodium.—(*Continued*)				
$Na_3HP_2O_7$—(*Cont'd*)	aq.	2982	N	(447)
$Na_3HP_2O_7.H_2O$	c	3264	4.7	(447)
$Na_3HP_2O_7.6H_2O$	c	4729	−29.6	(447)
$NaNH_4HPO_4$	aq.	1652	N	(129, 160)
$NaNH_4HPO_4.4H_2O$	c	2842	-45.0^{18}_{800}	(976)
Na_3AsO_4	c	1500 (?)	As + Na_2O_2	(710)
	500	1597	N	(976)
$Na_3AsO_4.12H_2O$	c	5084	-53^{18}_{600}	(569)
NaH_2AsO_3	400	952	N	(976)
NaH_2AsO_4	300	1143	N	(976)
Na_2HAsO_3	400	1137	N	(976)
Na_2HAsO_4	400	1377	N	(976)
Na_3SbO_4	c	1653	Sb + Na_2O_2	(710)
	aq.	1605	N; analogy	
$3Na_2S.Sb_2S_3$	1200	1561	+HCl; &	(127, 148, 463)
Na_3BiO_4 (?)	c	1181	Bi + Na_2O_2	(710)
Na_2C_2	c	−20	272_{HCl}; &	(381, 673)
Na_2CO_3	c	1132.3	23.6^{18}_{400}; &	(113, 361, 706, 777, 810,° 976, 978°)
	400	1155.8	N; &	(50, 742, 976)
	200	1157.1	dil.	(601,† 976)
	100	1158.9	dil.	
	50	1161.6	dil.	
	30	1164.0	dil.	
$Na_2CO_3.H_2O$	c	1432.6	9.4^{18}_{400}	(320,† 976)
$Na_2CO_3.7H_2O$	c	3204.2	-45^{18}_{400}	(320,† 976)
$Na_2CO_3.10H_2O$	c	4085.2	-67.6^{18}_{400}	(53, 360.5, 810, 976, 978°)
$Na_2C_2O_4$	c	1322.5	-23_{1500}	(56)
	450	1299.2	N	(53, 976)
$NaHC_2$	c	−105	61; &	(673)
$NaCHO_2$	c	657.1	-2.2^{12}_{150}	(55)
	400	654.9	N	(73, 976)
$NaHCO_3$	c	952	-18^{15}; &	(56, 263*)
	200	934.7	N	(50, 56, 976)
$NaHCO_3.H_2O$	c	1064	dissoc.*	(263*)
$NaCH_3O$	CH_3OH	452	Na + CH_3OH	(376)
$NaHC_2O_4$	c	1079	-23_{200}	(53)
	400	1056	N	(53, 976)
$NaHC_2O_4.H_2O$	c	1382	-40_{300}	(53, 976)
$NaC_2H_3O_2$	c	716.3	16.5^{18}_{200}	(55, 810,° 976)
	400	732.8	N; &	(73, 114, 671, 976)
	100	732.7	dil.	(51, 976)
	50	732.5	dil.	
	25	732.1	dil.	
	10	730.7	dil.	
	3	730	→$NaC_2H_3O_2.3H_2O$	(455)
$NaC_2H_3O_2.3H_2O$	c	1610	-19.2_{400}	(53)
NaC_2H_5O	C_2H_5OH	463	Na+C_2H_5OH	(376)
	c	413	56.4^{20}	(373)
$NaHC_4H_4O_6$	c	1509	−23.7	(56, 134)
	aq.	1486	N	(56, 134)
$NaHC_4H_4O_6.H_2O$	c	1807	−35.7	(56, 134)
$NaC_2H_3O_2.HC_2H_3O_2$	c	1219	8_{250}	(86)
$NaC_2H_3O_2.2HC_2H_3O_2$	c	1740	−20	(53)
$NaC_2H_5O.2C_2H_5OH$	c	998	43.8	(373)
$NaC_2H_5O.3C_2H_5OH$	c	1276	51.4	(373)
$Na_2C_4H_4O_6$	c	1725	−4.7	(56, 134)
	aq.	1721	N	(56, 134)
$Na_2C_4H_4O_6.2H_2O$	c	2318	−24.6	(56, 134)
$NaC_2H_5SO_4$	aq.	1145	$Ba(C_2H_5SO_4)_2$ + Na_2SO_4	(976)
NaCN	c	96	-2.1^{9}_{100}	(555)
	200	94	N	(976)
$NaCN.\frac{1}{2}H_2O$	c	241	-4.2^{6}_{110}	(555)
$NaCN.2H_2O$	c	685	-18.5^{4}_{100}	(555)
NaCNO	c	406	-20.1^{13}_{2000}	(626)
	aq.	386	+HCl	(626)
$Na_3C_3N_3O_3$	c	1274	6.1^{21}_{1500}	(626)
	aq.	1280	N	(626)
$NaCN_2H$	aq.	146	N	(626)
$NaH_2C_3N_3O_3$	c	911	-20.5_{3000}	(626)
$NaH_2C_3N_3O_3$.—(*Cont'd*)	aq.	890	N	(626)
$NaH_2C_3N_3O_3.H_2O$	c	1214	-37.1^{18}_{3000}	(626)
$Na_2HC_3N_3O_3$	c	1098	-7.4^{20}_{1500}	(626)
	aq.	1091	N	(626)
NaCNS	c	179	-13.9^{18}_{100}	(1023)
	aq.	165	N	(555)
Na_2SiO_3	gls.	1545	SiO_2 + Na_2O_2	(275, 706)
	c	1544	234.1_{HF}	(683, 740)
Na_2SiF_6	c	2766	N	(1001, 1090*)
	aq.	2755	N; &	(976, 1001, 1090*)
$Na_2O_2.TiO_3$ (from Ti + Na_2O_2)	c	2102	Ti + Na_2O_2	(706)
Na_2TiF_6	aq.	2808	N = H_2SiF_6	(189)
NaSn	c	46	$485_{HCl(g)}$ + $FeCl_3$	(189)
$NaSn_2$	c	63	$741_{HCl(g)}$ + $FeCl_3$	(189)
Na_2Sn	c	50	$741_{HCl(g)}$ + $FeCl_3$	(189)
Na_4Sn	c	88	$1218_{HCl(g)}$ + $FeCl_3$	(189)
Na_4Sn_3	c	151	$1695_{HCl(g)}$ + $FeCl_3$	(189)
Na_2SnO_2	aq.	937.3	$HSnCl_3$ + NaOH	(976)
Na_4SnO_4 (?)	c	1549	Sn + Na_2O_2	(708)
	aq.	1897	$SnCl_4$ + NaOH	(976)
$NaPbO_3$	c	842	Na_2O_2 + Pb	(709)
$2Na_2S_2O_3.PbS_2O_3$	c	2770	−17	(369)
	aq.	2753	mix.	(369)
$NaCl.ThCl_4.10H_2O$	c	4933	−24.0	(268)
$2NaCl.ThCl_4$	c	2244	209.4	(268)
Na_2ZnO_2	c	778	Na_2O_2 + Zn	(712)
$Na_2Zn(SO_4)_2$	c	2364	+41	(459)
	aq.	2406	mix.	(459)
$Na_2Zn(SO_4)_2.4H_2O$	c	3551	−0.7	(459)
$NaCd_2$	c	36	+Br	(187)
$NaCd_5$	c	52	+Br	(187)
Na_2CdO_2 (?)	c	681	Cd + Na_2O_2	(715)
$NaHg_2$	c	46	195_{HCl}	(89)
$NaHg_4$	c	78	163_{HCl}	(89)
Na_3Hg	c	53.8	199.3_{Hg}	(1030)
$NaHg_{27.5}$	liq.	82.01	dil.	(256,† 859†)
$NaHg_{59.0}$	liq.	82.82	dil.	(256,† 859†)
$NaHg_{115}$	liq.	83.11	Na + Hg	(646,* 1030)
$NaHg_{290}$	liq.	83.29	dil.	(256,† 859†)
$NaHg_{583}$	liq.	83.41	dil.	(256,† 859†)
$NaBr.HgBr_2$	4200	522	mix.	(1012)
$2NaBr.HgBr_2$	4400	887	mix.	(1012)
$4NaBr.HgBr_2$	4800	1614	mix.	(1012)
$4Na_2S.HgS$	aq.	2259	Na_2S+$HgCl_2$	(140)
$NaCN.Hg(CN)_2$	400	− 149	mix.	(1009)
$2NaCN.Hg(CN)_2$	600	− 32	mix.	(1009)
$NaCl.Hg(CN)_2$	1000	134	mix.	(1009)
$NaCl.Hg(CN)_2.1\frac{1}{2}H_2O$	c	526	-33.9^{15}	(1009)
$NaBr.Hg(CN)_2$	1000.	90	mix.	(1009)
$NaBr.Hg(CN)_2.2H_2O$	c	713.1	-50.5^{15}	(1009)
$NaI.Hg(CN)_2$	1000	35	mix.	(1009)
$NaI.Hg(CN)_2.2H_2O$	c	655	-48^{15}	(1006)
$Na_2O.CuO_2$	c	684	Cu + Na_2O_2	(713)
$Na_2O.Ag_2O_2$ (?) (from Ag and Na_2O_2)	c	601	Ag + Na_2O_2	(713)
$Na_2Ag(S_2O_3)_2$	c	1881	$AgNO_3$ + $Na_2S_2O_3$	(389)
$NaAg(CN)_2$	500	− 18.2	AgCN + NaCN	(1011)
$Na_3Ag(CN)_4$	1200	78	AgCN + NaCN	(1011)
$NaClO_3$ + $AgClO_3$(solid solutions)	■			(371)
Na_2PtCl_4	c	950	42; analogy	
	aq.	992	Na_2PtCl_4 + CuCl; &	(976)
Na_2PtCl_6	c	1138	35.6^{18}_{800}	(976)
	aq.	1173	+Co	(976)

Formula	State	Q, kj	Method	Lit.
Sodium.—(*Continued*)				
$Na_2PtCl_6.2H_2O$	c	1747	-0.8^{18}_{800}	(976)
$Na_2PtCl_6.6H_2O$	c	2935	-44.4^{18}_{900}	(976)
Na_2PtBr_6	c	924	41.6^{18}_{800}	(976)
	aq.	966	+Co	(976)
$Na_2PtBr_6.6H_2O$	c	2719	-36^{18}_{800}	(976)
Na_2PtI_6	aq.	699	+Co	(816)
Na_3RhCl_6	c	1426	32.2^{18}_{6000}	(453)
	aq.	1458	+Co	(453)
$Na_3RhCl_6.12H_2O$	c	4978	-86.0^{17}_{5000}	(453)
Na_2PdCl_4	aq.	1014	ions	
Na_2MnO_4	c	1120	Mn + Na_2O_2	(712)
$Na_2SO_4.MnSO_4$	c	2406	54	(458)
	aq.	2460	mix.	(458)
$Na_2SO_4.MnSO_4.2H_2O$	c	2601	13	(458)
$Na_2SO_4.MnSO_4.6H_2O$	c	4218	−41	(458)
$Na_4FeCO(CN)_5$	c	522	20^{13}_{3600}	(711)
	aq.	542	N	(747, 748)
$Na_4FeCO(CN)_5.7H_2O$	c	2577	-31^{17}_{5600}	(747, 748)
Na_2CoO_2	c	833	Co + Na_2O_2	(712)
$2NaBr.CoBr_2$	900	1028	mix.	(1012)
$Na_2Ni(CN)_4$	aq.	143	$Ni(CN)_2$ + NaCN	(1011)
Na_2CrO_4	c	1325	10.0^{11}_{600}	(87, 707, 716)
	[illegible]	1335	N	(976)
	10	135c	→ $Na_2CrO_4.10H_2O$	(731)
$Na_2CrO_4.4H_2O$	c	2510	-32^{11}_{1000}	(86)
$Na_2CrO_4.10H_2O$	c	4262	-66.1^{11}_{1200}	(86)
$Na_2Cr_2O_7$	aq.	1920.3	ions	(785)
$Na_2MoO_{4(I)}$	c		Tr.; $61.1^{440}_{(II)}$	(1091)
$Na_2MoO_{4(II)}$	c	1514	Na_2O_2 + Mo	(712)
	400	1501	N	(785)
$Na_2WO_{4(I)}$	c		Tr.; $39.8^{579}_{(II)}$	(1091)
$Na_2WO_{4(II)}$	c	1624	W + Na_2O_2	(707)
	aq.	1607	17; analogy	
Na_2UO_4	c	1759	U + Na_2O_2	(714)
$Na_2U_2O_7.1\frac{1}{2}H_2O$	c	1910	$186_{H_2SO_4}$	(820)
$(Na_2O_2)_2UO_4$	aq.	5773	UO_2SO_4 + Na_2O_2 + H_2SO_4	(820)
$(Na_2O_2)_2UO_4.9H_2O$	c	5780	UO_2SO_4 + Na_2O_2 + H_2SO_4	(820)
$NaVO_3$	aq.	118c	V_2O_5 + $NaHO_2$	(891)
Na_3VO_4	c	188c	V + Na_2O_2	(714)
$NaBO_2$	300	969	N	(50, 59, 84, 976)
$Na_2B_4O_7$	c	3106	43	(43.1, 350, 361)
	aq.	3149	N	(50, 59, 976)
$Na_2B_4O_7.10H_2O$	c	6119	-108.2^{18}_{1600}	(216, 360.5, 976)
Na_2BO_2 (?)	c	1405	B_2O_3 + Na_2O_2	(707)
	aq.	1622	N	(50, 59, 976)
$NaAlO_2$	c	1137	Na_2O+Al_2O_3	(716)
$3NaF.AlF_3$	c	3113	$123_{(19\%\ HF)}$	(32)
	aq.	3256	mix.	(32)
$3NaF.AlF_3.3\frac{1}{2}H_2O$	c	4208	−54.1; &	(32)
$NaCl.AlCl_3$	c	1134	296^{15}_{800}	(32)
$NaCl.AlCl_3.6NH_3$	c	1936	23.5	(32)
$3NaCl.2AlCl_3$	c	2693	573.2^{15}_{2000}	(32)
$Na_2O.Al_2O_3.3SiO_2$(dehydr. natrolite)	c (?)	3689	$790_{(20\%\ HF)}$	(740)
$Na_2O.Al_2O_3.4SiO_2$(dehydr. analcite)	c (?)	5733	$970_{(20\%\ HF)}$	(740)
Na_4CeO_4 (?)	c	(?)	Ce_2O_3 + Na_2O_2	(709)
$2Na_2SO_4.CaSO_4$	c	2782	13.0_{1000}	(30)
$2Na_2SO_4.CaSO_4.2H_2O$	c	4731	3.8_{1200}	(30)
$NaMnPO_4.\frac{1}{2}H_2O$	c	4802	N	(569)
$NaSrAsO_4.9H_2O$	c	4295	N	(569)
$NaBaPO_4.9H_2O$	c	4674	$BaCl_2$ + NaH_2PO_4	(569)
$NaBaAsO_4.9H_2O$	[illegible]	4289	$BaCl_2$ + NaH_2AsO_4	(569)

Formula	State	Q, kj	Method	Lit.
Potassium[a]				
K	c	0	Def.	
	gas	− 86	→ c	(366*)
K^+	∞	252.4	KCl; &	
K_2O	c	361	314^{17}_{300}	(40, 854)
K_2O_2	c	517	$182.3^{18}_{H_2SO_4}$	(419)
K_2O_4	c	550	$142.9_{H_2SO_4}$	(418)
KH	c	59	dissoc.*	(579,* 736*)
$KOH_{(\beta)}$	c	426.9	54.2^{21}_{175}	(49, 55, 65, 219, 392, 976)
$KOH_{(\alpha)}$	c		Tr.; $6.4^{248}_{(\beta)}$	(515)
(*see also* p. 161)	∞	480.64	dil.	
	400	480.47	dil.	
	200	480.35	K + H_2O; &	(359, 558, 854, 976)
	100	480.30	dil.	(65, 408, 827,° 867,° 897, 976)
	50	480.29	dil.	
	25	480.18	dil.	
	15	479.80	dil.	
	9	478.73	dil.	
	7	477.61	dil.	
	5	475.10	dil.	
	3	468.85	dil.	
$KOH.\frac{1}{2}H_2O$	c	678	18.0^{21}_{175}	(219, 392)
$KOH.H_2O$	c	752	14.9^{21}_{175}	(219, 392)
$KOH.2H_2O$	c	1052	-0.1^{11}_{170}	(65, 219)
KF	c	561.2	17.2^{15}_{110}	(410, 465)
	400	578.4	N; &	(157, 465, 740, 976)
	5.76	576.8	dil.	(412)
	3.90	573.9	dil.	
$KF.2H_2O$	c	1159.7	-9.0^{15}_{110}	(412, 465)
$KF.4H_2O$	c	1748.7	−25.8	(412)
KHF_2	c	918	-25^{15}_{400}	(412, 464, 465)
	400	893	N; &	(464, 465, 976)
KF.2HF	c	1242	−33	(471)
KF.3HF	c	1561	−36	(471)
KCl	c	436.5	-18.6^{18}_{200}; &	(16, 157.5,° 245,† 290, 295,° 312,† 493, 623,° 729, 777, 810,° 840, 934,† 976, 1006,° 1046°)
(*see also* p. 161)	gas	22o	→c	(366,* 492*)
	∞	417.99	dil.	(198, 245, 501.5,° 623,° 653, 827,° 868,° 890,† 909, 934,† 938,† 1006°)
	1000	417.91	dil.	
	500	417.88	dil.	

[a] Heats of solution of melted salt mixtures:

	Fresh melt	Old melt	Lit.
KCl.NaCl	−20.2	-20.8^{15}	(157.5, 777, 1023)
KCl.2NaCl	-22.6^{15}	-25.1^{15}	
2KCl.NaCl	-30.4^{13}	-35.7^{13}	
KI.NaCl	-23.3_{150}		(45)
$K_2SO_4.Na_2SO_4$	-23^{12}	-21.2^{16}	
$K_2SO_4.2Na_2SO_4$	-16.1^{12}	-15.1^{16}	
$2K_2SO_4.Na_2SO_4$	-55.7^{12}	-52.0^{10}	
$K_2CO_3.Na_2CO_3$	34.4^{12}	33.9^{14}	
$K_2CO_3.2Na_2CO_3$	64.9^{11}	64.2^{15}	
$K_2CO_3.3Na_2CO_3$	97.5^{14}	94.1^{14}	
$K_2CO_3.4Na_2CO_3$	129.3^{14}	127.5^{16}	
$2K_2CO_3.Na_2CO_3$	55.3^{12}	55.5	
$3K_2CO_3.Na_2CO_3$	101^{13}	101^{15}	(157.5)

$KCl.BrCl_2$ mixtures, partial heat of dilution (938).
Solid solutions of KCNS and NaCNS, heats of formation (1023).
$KAuCl_4$, heat of dissociation (780.5).
KCl, HCl, partial heat content of HCl (500, 501).
$K_2SO_4.CoSO_4.6H_2O$, $K_2SO_4.ZnSO_4.6H_2O$, $K_2SO_4.NiSO_4.6H_2O$, heats of dehydration (262).

Formula	State	Q, kj	Method	Lit.
Potassium.—(*Continued*)				
KCl.—(*Continued*)	200	417.93	N	(50, 742, 868,°
	100	418.02	dil.	976)
	50	418.73	dil.	
	25	419.53	dil.	
KClO	400	360.5	KOH + Cl_2; &	(976)
$KClO_3$	c	376.1	-43.0^{18}_{400}	(55, 216, 428, 934, 947, 976, 1019)
	∞	332.2	dil.	(934†)
	500	332.9	dil.	
	400	333.1	N; &	(947, 976)
	250	333.8	dil.	
	125	334.9	dil.	
$KClO_4$	c	469	$+NH_4C_6H_2(NO_2)_3O$	(174)
	∞	415.3	dil.	(934†)
	1000	417.0	dil.	(761)
	500	421	dil.	
	sat.	420	−49.0	(174, 761 934†)
KBr	c	393.5	-21.2^{18}_{200}; &	(55, 67, 157.5,° 245,† 976, 1024)
	gas	184	→ c	(366*)
	∞	372.0	ions	
	200	372.30	N; &	(63, 868,° 976)
	50	372.5	dil.	(324,† 890,† 976)
	10	375.4	dil.	(976)
KBr_3	aq.	382	KBr + Br_2*	(648*)
KBr_5	aq.	401	KBr_3 + Br_2*	(648*)
KBrO	aq.	344	ions	
$KBrO_3$	c	347.8	-42^{18}_{400}	(81, 934,† 976)
	∞	305.0	dil.	(934)
	500	305.6	dil.	
	400	305.9	N	(976)
	250	306.0	dil.	
KBr.KCl(solid solutions)				(157.5, 959, 1023)
KI	c	329.6	-21.4^{18}_{400}	(111, 976)
	gas	134	→ c	(366°)
	∞	308.1	ions	(55, 909)
	200	308.35	N	(63, 868,° 976)
	100	308.5	dil.	(324)
KI_3	aq.	301	I_2 + KI; &	(1, 94, 811)
KIO	aq.	331	KOH + I_2	(82, 924, 925)
KIO_3	c	508.4	-28.3^{18}_{400}	(82, 934, 976)
	∞	479.2	dil.	(934)
	500	479.7	dil.	
	400	480.1	N; &	(80, 82, 976)
	250	480.7	dil.	
KIO_4	aq.	409	N	(976)
K_3IO_5	aq.	1186.7	N	(976)
K_5IO_6	aq.	1871	N	(80, 976)
KH_4IO_6	400	981	N	(976)
$KIO_3.HIO_3$	c	758	-49^{12}_{800}	(82)
	aq.	709	mix.	(976)
$K_2H_3IO_6$	aq.	1265	N	(80, 976)
$K_3H_2IO_6$	aq.	1473	N	(80, 976)
KI.KCl(fresh melt)	c	765	−38	(45, 157.5)
KI.KBr(fresh melt)	c	718	−38	(157.5, 1023)
K_2S	c	369	94	(359, 856, 897)
	400	462.8	dil.	(897)
	200	463.1	N; &	(897, 976)
	100	463.4	dil.	
	50	464.1	dil.	
	20	464.5	dil.	
	10	459.3	dil.	
	7	453.6	dil.	
$K_2S.2H_2O$	c	1019	16^{18}_{1200}	(897)
$K_2S.5H_2O$	c	1915	-22^{16}_{1000}	(897)
K_2S_4	c	476	5^{10}_{100}	(897)
	aq.	481	+HI	(597)

Formula	State	Q, kj	Method	Lit.
Potassium.—(*Continued*)				
$K_2S_4.\frac{1}{2}H_2O$	c	633	-9.2^{13}	(897)
$K_2S_4.2H_2O$	c	1085	-31^{12}	(897)
K_2SO_3	c	1113	6^{12}_{300}; &	(116, 669)
	600	1119	N; &	(116, 976)
$K_2SO_3.H_2O$	c	1400	5_{300}	(116)
$K_2SO_{4(I)}$	c		Tr.; $10.75^{569}_{(II)}$	(1091)
$K_2SO_{4(II)}$	c	1417.1	-27.4^{18}_{400}	(49, 157.5° 245, 355, 359, 805,° 810, 909, 976, 978,° 1006°)
	∞	1389.1	ions	
	800	1389.5	dil.	(245,† 890†)
	400	1389.7	dil.	(1006°)
	200	1390.8	N; &	(748, 976)
	100	1392.4	dil.	
	50	1394.9	dil.	
$K_2S_2O_3$	c	1116	-21^{10}_{800}	(117, 123, 669)
	aq.	1095	N	(976)
$K_2S_2O_3.H_2O$	c	1407	-26^{14}	(999)
$K_2S_2O_5$	c	1500	-47.0^{13}_{450}	(118)
	600	1452	N	(118)
$K_2S_2O_5.\frac{1}{2}H_2O$ (?)	c	1643	-47.5^{13}_{450}	(118)
$K_2S_2O_6$	c	1707.1	dissoc.	(669, 976)
	500	1653	-54.4^{19}_{500}	(976)
$K_2S_2O_7$	c	1954	−16	(53)
	aq.	1938	dissoc.	(53)
$K_2S_2O_8$	c	1861	-61^{9}_{3300}	(135°)
	aq.	1800	BaS_2O_8 + K_2SO_4; &	(135°)
$K_2S_3O_6$	c	1650	-52.1^{18}_{500}; &	(131, 669, 976)
	aq.	1598	+Br_2	(131)
$K_2S_4O_6$	c	1655	-55.0^{17}_{500}	(669)
	aq.	1600	ions	
$K_2S_5O_6$	c	1666	−42	(669)
	aq.	1624	ions	
$K_2S_5O_6.\frac{1}{2}H_2O$	c	2108	-55^{10}_{2000}	(131)
KHS	400	267.7	dil.	(897)
	200	267.8	N	(976)
	50	269.3	dil.	
	20	272.1	dil.	
	10	272.4	dil.	
	6	268.6	dil.	
$KHS.\frac{1}{2}H_2O$	c	336	3.2^{17}_{1000}	(897)
$KHSO_3$	400	869.4	N	(116, 976)
$KHSO_{4(III)}$	c	1142	-15.9^{17}_{200}	(52, 355, 458, 976)
$KHSO_{4(II)}$	c		Tr.; $2.0^{180}_{(III)}$	(235*)
$KHSO_{4(I)}$	c		Tr.; $0.40^{184}_{(II)}$	(235*)
$KHSO_4$	800	1128.9	dil.	(52, 976)
	400	1127.2	dil.	
	200	1126.1	N; &	(52, 976)
	100	1125.5	dil.	
	50	1125.4	dil.	
	20	1125.6	dil.	(976)
$KI.4SO_3$	c	1654	dissoc.*	(342*)
K_2Se	c	357	36^{13}_{1800}	(350)
	aq.	393	N	(350)
$K_2Se.9H_2O$	c	3048	-80^{14}_{4000}	(350)
$K_2Se.14H_2O$	c	4484	-85^{13}_{4000}	(350)
$K_2Se.19H_2O$	c	5952	-123^{14}	(350)
KHSe	aq.	198	N	(350)
K_2TeO_3	aq.	1085	N	(696)
K_2TeO_4	aq.	1227	N	(696)
KNO_2	aq.	359	N; &	(58, 954)
$KNO_{3(I)}$	c		Tr.; $2.6^{126}_{(III)}$	(45.3, 234*)
$KNO_{3(III)}$	c		Tr.; $4.9^{128}_{(II)}$	(45.3, 234*)
$KNO_{3(II)}$	c	497.1	-35.4^{18}_{200}	(9, 52, 294,°†
(*see also* p. 162)	∞	460.81	dil.	493, 634,
	1000	460.94	dil.	729, 810,°
	500	461.06	dil.	909,° 934,†

Formula	State	Q. kj	Method	Lit.
Potassium.—(*Continued*)				
$KNO_3.H$ —(*Continued*)				976, 978,* 1006,† 1048*
	200	461.60	N; &	(52, 868,* 976)
	100	462.74	dil.	(52, 198, 827,* 867,* 896, 934†)
	50	464.49	dil.	(1086*)
	25	467.17	dil.	
	sat.	468.0	dil.	(294, 934†)
K_2NO_2	aq.	489	$Sr(NO)_2$ + K_2SO_4	(133)
KNH_2	c	73	dissoc.; &	(559)
$KBr.4NH_3$	c	606	dissoc.*	(1870)
$KI.4NH_3$	c	641	dissoc.*	(1870)
$KI.6NH_3$	c	794	dissoc.*	(1870)
K_3PO_4	aq.	2006	N	(976)
KH_2PO_2	aq.	849	N	(976)
$K_2H_2PO_2$	aq.	1214	N	(976)
KH_2PO_3	c	1557	−20	(458)
	aq.	1537	N	(976)
K_2HPO_3	aq.	1465	N	(976)
K_2HPO_4	aq.	1783	N	(976)
K_3AsO_4	400	1631	N	(976)
KH_2AsO_3	800	963	N	(976)
KH_2AsO_4	c	1175	−20	(458)
	400	1155	N	(976)
K_2HAsO_3	400	1160	N	(976)
K_2HAsO_4	400	1402	N	(976)
K_2CO_3	c	1150.7	27.2^{16}_{400}; &	(53, 157.5,* 614, 777, 976)
	400	1177.9	dil.	976)
	200	1178.5	N; &	(52, 742, 976)
	100	1179.3	dil.	(485, 890,†
	50	1180.5	dil.	976)
	10	1182.0	dil.	
$K_2CO_3.\frac{1}{2}H_2O$	c	1309.0	17.9^{16}_{400}	(976)
$K_2CO_3.1\frac{1}{2}H_2O$	c	1608.7	-1.6^{18}_{400}	(55,* 976)
$K_2C_2O_4$	c	1341	−20	360
	3200	1321.6	dil.	(318)
	1600	1321.7	dil.	(318)
	800	1322.0	N; &	36, 976)
	400	1322.5	dil.	318)
	200	1323.5	dil.	318
	133	1323.1	dil.	318)
$K_2C_2O_4.H_2O$	c	1689.0	-31.0^{15}_{500}	(976)
$7K_2CO_3.2CO_2.9\frac{1}{2}H_2O$	c	1232.4	-91.4^{15}_{400}	(486)
$KHCO_2$	c	669.1	-3.9^{15}_{23}	55)
	400	663.2	N	(55, 63, 976)
$KHCO_3$	c	968	-22.3^{15}_{220}; &	(53, 264,* 496, 632†)
	200	945	N; &	52, 742, 976)
KCH_3O	CH_3OH	464	K − CH_3OH	376)
KHC_2O_4	c	1007	−40	459)
	400	2007.3	N	55, 976)
$KC_2H_3O_2$	c	730.2	14.0^{25}_{200}	55, 976)
	400	744.2	N	42, 976)
	200	744.0	dil.	(976)
	100	743.7	dil.	
	50	743.2	dil.	
	25	742.8	dil.	
	10	740.7	dil.	
	5	737.4	dil.	
KC_2H_5O	C_2H_5OH	481.9	K + C_2H_5OH	(310, 376)
$KHC_2H_2O_4$	c	1946	−66	(459)
$KHC_4H_5O_6$	c	1545	−43HCl	(468, 555)
	aq.	1497	N	56, 134, 982)
$K_2C_4H_4O_4$	c	1755	-11.9^{15}_{400}	56, 134, 468, 510)
	aq.	1743	N	(55, 134, 150, 982)
$K_2C_4H_4O_6.\frac{1}{2}H_2O$	c	1919	-25.7^{17}_{400}	(56, 310, 982)
$K_2C_4H_4O_6.2H_2O$	c	2363	−45.6	(982)
KCN	c	118	-12.5^{18}_{500}	55, 79, 976)
	200	105	N; &	74, 133, 976)
KCNO	c	419	-23.6^{20}_{400}	53)
	aq.	397	−HCl; &	137)

Formula	State	Q. kj	Method	Lit
Potassium.—(*Continued*)				
$K_2C_2N_2O_2$	c	1341	-25^{25}_{600}	(626)
	aq.	1317	N	(626)
$KH_2C_2N_2O_2$	c	938	-35.9_{1500}	(626)
	aq.	902	N	(626)
$KHC_2N_2O_2.H_2O$	c	1233	-45.4^{21}_{1500}	(626)
$K_2HC_2N_2O_2$	c	1114	-29_{1455}	626)
	aq.	1088	N	(626)
KCNS	c	227	-51_{150}	(555, 1023)
	aq.	176	K_2S_2 + KCN; &	(555, 1023)
$KHCN_2$	aq.	159	N	(626)
$KCNS.SO_2$	c	562	dissoc.*	(342*)
$2KCNS.SO_2$	c	792	dissoc.*	(342*)
$KSbOC_4H_2O_3$	c	1453	2	(469)
$KSbOC_4H_4O_6$	c	1763	-21^{18}	(469)
	aq.	1741	N	(469)
$KSbOC_4H_4O_6.\frac{1}{2}H_2O$	c	1907	-22^{18}	(469)
K_2SiF_6	c	2854	N	(1001)
	aq.	2794	N; &*	(1002*)
K_2SnCl_6	c	1507.3	-14.1^{12}_{300}	(976)
	600	1493.2	KCl + $SnCl_4$	(976)
$K_2SnCl_6.H_2O$	c	1520	-56.2^{18}_{600}	(976)
$KCl.PbCl_2.\frac{1}{2}H_2O$	c	896.0	KCl + $PbCl_2$	(246*)
$KCl.2PbCl_2$	c	1162.8	KCl + $PbCl_2$	(246*)
$2KI.PbI_{2(cr)}$	c	888	-40.1	(111)
$2KI.PbI_2.2H_2O$	c	1429	-66.2^{25}_{2000}	(111)
$4KI.3PbI_{2(fresh\ melt)}$	c	1839	-81_{1500}	(111)
$4KI.3PbI_2.6H_2O$	c	3608	-132^{18}_{2000}	(111)
$K_2SO_4.PbSO_4$	c	2336.1	K_2SO_4 + $PbSO_4$; &	(30, 245*)
$KCl.ThCl_4.9H_2O$	c	4621	12.8	(268)
$2KCl.ThCl_4$	c	2313	1675	268)
$K_2Zn(SO_4)_2$	c	2894	38.1^{18}_{600}	(458, 976)
$K_2Zn(SO_4)_2.2H_2O$	c	2998	2.0^{18}_{600}	(976)
$K_2Zn(SO_4)_2.6H_2O$	c	4194	-49.4^{18}_{600}	(458, 976)
$2KCN.Zn(CN)_2$	c	122	63^{15}_{600}	(140, 535*)
$8KCN.Zn(CN)_2$	aq.	825	mix.	(139)
$KHg_{(l)}$	c	60	19.1_{HCl}	140)
KHg_2	c	121	133_{HCl}	59)
KHg_4	c	167	341_{HCl}	59)
$KHg_{12(l)}$	liq.	1109.0	K + Hg	535,* 927)
$KCl.HgCl_2$	c	669	-40.5^{18}_{25}	106)
	aq.	629	mix.	(106)
$KCl.HgCl_2.H_2O$	c	968	-47.5^{14}_{200}	106)
$2KCl.HgCl_2$	c	1046	-62.9^{14}_{2000}	106
	400	1053	mix.	(976
$2KCl.HgCl_2.H_2O$	c	1408	-68.6^{18}_{600}	(106, 976)
$4KCl.3HgCl_2$	c	2449	-141^{18}	106)
	aq.	2308	mix.	106)
$4KCl.3HgCl_2.3H_2O$	c	3330	-164	106)
$KBr.HgBr_2$	c	577	$-11.4^{24}_{KBr_{600}}$	105
	4200	566.6	mix.	106, 1012)
$KBr.HgBr_2.H_2O$	c	875	-26.8^{18}_{600}	106, 976)
$2KBr.HgBr_2$	c	962	-40.5^{18}_{600}	106, 976)
	4400	910	mix.	(106, 1012)
	660	921	mix.	(976)
$4KBr.HgBr_2$	4800	1061	mix.	1012)
$KI.HgI_2$	c	444	-30	106
$KI.HgI_2.H_2O$	c	701	-54	106)
$2KI.HgI_2$	c	778	-41.0^{18}_{600}	(976)
	600	737	HgI_2 + KI	(976)
$3KI.HgI_2$	aq.	1048	HgI_2 + KI	(109)
$6KI.HgI_2$	aq.	1980	HgI_2 + KI	(109)
$KCN.Hg(CN)_2$	400	− 147	mix.	1009
$2KCN.Hg(CN)_2$	c	92	−39	136
	600	− 7	mix.	(140)
$KCl.Hg(CN)_2$	c	184	−38	(109)
	500	146	mix.	(109)
$KCl.Hg(CN)_2.H_2O$	c	476	−43	109)
$KCl.2Hg(CN)_2$	1000	− 126	mix.	109)
$2KCl.Hg(CN)_2$	600	365	mix.	109)
$4KCl.Hg(CN)_2$	800	1402	mix.	109)
$8KCl.Hg(CN)_2$	1200	3075	mix.	109

Formula	State	Q, kj	Method	Lit.
Potassium.—(*Continued*)				
$KBr.Hg(CN)_2$	c	151	-50^{14}	(106)
	500	102	mix.	(106)
$KBr.Hg(CN)_2.1\frac{1}{2}H_2O$	c	584	-53^{14}	(106, 1009)
$KBr.2Hg(CN)_2$	1000	− 170	mix.	(106)
$2KBr.Hg(CN)_2$	600	475	mix.	(106)
$4KBr.Hg(CN)_2$	800	1222	mix.	(106)
$8KBr.Hg(CN)_2$	1200	2714	mix.	(106)
$KI.Hg(CN)_2$	c	97	-50^{14}	(106)
	500	47	mix.	(106)
$KI.Hg(CN)_2.\frac{1}{2}H_2O$	c	171	-52^{14}	(106)
$KI.2Hg(CN)_2$	1000	− 224	mix.	(106)
$2KI.Hg(CN)_2$	600	360	mix.	(106)
$4KI.Hg(CN)_2$	800	980	mix.	(106)
$8KI.Hg(CN)_2$	1200	2216	mix.	(106)
$KCl.CuCl_2$	c	662.7	14.9^{16}_{200}	(1022)
$2KCl.CuCl$	c	1016	KCl + CuCl;*	(246)
$2KCl.CuCl_2$	c	1103.2	-5.9^{18}_{800}	(226)
$2KCl.CuCl_2.2H_2O$	c	1696	-26.7^{18}_{800}	(226, 360, 1022)
$K_2SO_4.CuSO_{4(\alpha)}$ (prepared below 180°)	c	2164	40.6^{18}_{600}	(810, 976)
$K_2SO_4.CuSO_{4(\beta)}$ (prepared bet. 180–200°)	c	2179	26	(360.5, 808)
$K_2SO_4.CuSO_4$(fused)	c	2169	35.2	(458, 808)
$K_2SO_4.CuSO_4.2H_2O$	c	2782	-4.8^{18}_{600}; &	(261,* 976)
$K_2SO_4.CuSO_4.6H_2O$	c	3978	-56.4^{18}_{800}	(355, 360.5, 458, 810)
$K_2Cu(CO_3)_{2(V)}$	c	1788	49.5_{HCl}	(814)
$K_2Cu(CO_3)_{2(II)}$	c	1777	60.5_{HCl}	(814)
$K_2Cu(CO_3)_{2(IV)}$	c	1786	51.9_{HCl}	(814)
$KI.AgI$	c	408	+aq.	(112)
$KI.AgI.\frac{1}{2}H_2O$	c	527	+aq.	(112)
$2KI.AgI.\frac{1}{2}H_2O$	c	865	+aq.	(112)
$3KI.AgI$	c	1071	+aq.	(112)
$3KI.AgI.\frac{1}{2}H_2O$	c	1193	+aq.	(112)
$KAg(CN)_2$	c	28	-35.8^{11}_{400}	(55, 113)
	500	− 7	KCN + AgCN	(140, 1011)
$K_2Ag(CN)_3$	1200	101	KCN + AgCN	(140, 1011)
$KAu(CN)_2$	aq.	26	$AuCl+KCN_{(s)}$	(1078)
K_2IrCl_6	c	117o	dissoc.*	(451, 453)
	aq.	111	-13^{16}	(453)
K_3IrCl_6	c	153o	K_2IrCl_6 + Co	(453, 454)
K_2PtCl_4	c	1066	−50.7; &	(976)
	aq.	1015	+Co; &	(976)
K_2PtCl_6	c	1254	Na_2PtCl_6 + KCl; &	(976)
	aq.	1198	−57.6	(976)
K_2PtBr_4	c	925	−44.2	(976)
	aq.	881	+Co; &	(816, 976)
K_2PtBr_6	c	1040	−51.3; &	(976)
	aq.	988	+Co; &	(976)
K_2PdCl_4	c	1094	-57.0^{19}_{300}	(976)
	aq.	1037	+Co; &	(556, 976)
K_2PdCl_6	c	1214	−63	(976)
	aq.	1151	+CuCl; &	(976)
K_2PdBr_4	aq.	872	Pd + KBr + Br_2	(556)
$KMnO_4$	c	813	-43.5^{18}_{1000}; &	(55, 723, 976)
	600	769	$+H_2O_2$; &	(68, 976)
$KFe(SO_4)_2$	aq.	2038	mix.	(69, 976)
$KFe(SO_4)_2.12H_2O$	c	5539	−67	(359)
$K_2Fe(SO_4)_2.4H_2O$	c	3551	dissoc.*	(262)
$K_2Fe(SO_4)_2.6H_2O$	c	4123	−46	(458)
$K_3Fe(CN)_6$	c	205	$-60.^{13}_{400}$	(555)
	aq.	144	$+Br_2$; &	(555)
$K_4Fe(CN)_6$	c	551	-52^{17}_{1000}	(55, 555, 910)
	aq.	499	N	(277, 555, 743)
$K_4Fe(CN)_6.3H_2O$	c	1427	-69^{17}_{1000}	(55, 910)
$K_3FeCO(CN)_5$	c	598	-22^{17}_{2200}	(746)
	aq.	576	N	(746)
$K_3FeCO(CN)_5.3\frac{1}{2}H_2O$	c	1623	-46^{18}_{2200}	(746)

Formula	State	Q, kj	Method	Lit.
Potassium.—(*Continued*)				
$KH_3Fe(CN)_6$	aq.	− 364	N	(555)
$KH_3Fe(CN)_6$	aq.	− 259	N	(277, 743)
$K_2HFe(CN)_6$	aq.	− 109	N	(555)
$K_2H_2Fe(CN)_6$	aq.	− 6	N	(277, 555, 743)
$K_3HFe(CN)_6$	aq.	247	N	(277, 555, 743)
$K_2Ni(CN)_4$	aq.	166	$Ni(CN)_2$ + KCN	(1011)
$K_2CrO_{4(I)}$	c		Tr.; $17.0^{664}_{(II)}$	(1091)
$K_2CrO_{4(II)}$	c	1379	-22.0_{640}	(458, 733)
	800	1357.2	N	(976)
$K_2Cr_2O_7$	c	2016.0	-73.0^{18}_{1000}	(120, 458, 733, 934,† 976)
	∞	1939.1	dil.	
	1200	1942.9	N	(119, 122, 899, 976)
	1000	1943.0	dil.	(934†)
	500	1945.4	dil.	
	250	1947.7	dil.	
	166	1949.1	dil.	
	sat.	1953.3	dil.	
$KOCrClO_2$	c	1016	19.5_{500}	(733)
$K_2Cr_2O_{10}$	c	2584	−59	(458)
	aq.	2525	N; analogy	
$KCr(SO_4)_2$	aq.	2274	+KOH	(122, 976)
KNH_4CrO_4	c	1263	-22_{250}	(899)
	600	1241	N	(899)
K_2MoO_4	aq.	1524	N	(785)
K_2MoO_5	aq.	1808	K_2MoO_4 + H_2O_2	(785)
$2KCl.UO_2Cl_2.2H_2O$	c	2764	−16	(7)
KVO_3	aq.	1318	$+H_2O_2$	(821)
KVO_4	aq.	1258	$+H_2O_2$	(821)
KVO_3	aq.	1196	ions	
$3KF.AlF_3$	c	3217	+HF	(32)
	aq.	3232	+HF	(32)
$3KF.AlF_3.3\frac{1}{2}H_2O$	c	4322.7	AlF_3 + KF	(32)
$KCl.AlCl_3$	c	1190	252.0^{15}_{800}	(32)
$3KCl.AlCl_3$	c	2082	195.2^{15}_{1500}	(32)
$3KCl.2AlCl_3$	c	2833	469.0^{15}_{2000}	(32)
$KAl(SO_4)_2$	600	2549	+KOH	(976)
$KAl(SO_4)_2.12H_2O$	c	6026	-42.3^{18}_{1200}	(359, 976)
$KCl.AlCl_3.6NH_3$	c	1984	−12.7	(32)
$K_2O.Al_2O_3.4SiO_2$	c	5789	+HF	(740)
	gls.	5700	+HF	(740)
$K_2O.Al_2O_3.6SiO_2$(adularia)	c	7579	$1094_{20\%\ HF}$	(740)
$K_2O.Al_2O_3.6SiO_2$(microcline)	c	7466	+HF	(740)
	gls.	7345	$1328_{20\%\ HF}$	(740)
$KCl.MgCl_2$(melt)	c	1091	118^{18}	(157.5)
$KCl.MgCl_2.6H_2O$	c	2939	-12.9^{15}	(157.5)
$2KCl.MgCl_2$(melt)	c	1530	98^{16}	(157.5)
$4KCl.MgCl_2$	c	2407	56^{16}	(157.5)
$K_2Mg(SO_4)_2$	c	2690	44^{19}_{600}	(157.5, 808, 810, 976)
$K_2Mg(SO_4)_2.2H_2O$	c	3303	3.8^{18}_{600}	(976)
$K_2Mg(SO_4)_2.4H_2O$	c	3922	dissoc.;* &	(262)
$K_2Mg(SO_4)_2.5H_2O$	c	4200	-34.5^{18}_{800}	(976)
$K_2Mg(SO_4)_2.6H_2O$	c	4493	-41.9^{18}_{600}	(458, 810, 976)
$2KCl.CaCl_2$(melt)	c	1684	25^{14}	(157.5)
$K_2SO_4.CaSO_4.H_2O$	c	3133	−30.2	(30)
$K_2SO_4.5CaSO_4.H_2O$	c	8809	3.0	(30)
$KCaFeCO(CN)_6.5H_2O$	c	1859	$+O_2$	(622)
$K_2SO_4.SrSO_4$	c	2844	-26.1_{1000}	(30)
$KI.LiCl$(melt)	c	737	14.0_{180}	(45)
NaK	liq.	8	368.8	(558)
NaK_2	liq.	25	546.7	
NaK_3	liq.	22	743	
Na_2K	liq.	5	559	
$KNaC_4H_4O_6$	c	1740	7.8	(56)
	aq.	1732	N	(56)
$KNaC_4H_4O_6.4H_2O$	c	2928	−50.8	(56, 247, 359)
3KCNS.NaCNS	c	844	−150.7	(1023)

Formula	State	Q, kj	Method	Lit.
Rubidium[a]				
Rb	c	0	Def.	
Rb^+	∞	256	RbCl	
Rb_2O	c	347	335^{19}	(41, 853, 854)
Rb_2O_2	c	448	$+H_2SO_4$	(419)
Rb_2O_4	c	565	analogy	(419)
$RbOH_{(\beta)}$	c	423.5	59.7^{15}_{110}	(397)
$RbOH_{(\alpha)}$	c		Tr.; $7.1^{245}_{(\beta)}$	(515)
	100	483.9	$Rb + H_2O$	(41, 854)
	3.18	472.9	dil.	(408)
$RbOH.(H_2O)_{0.613}$	c		32.1^{15}_{110}	(397)
$RbOH.H_2O$	c	754	16.1^{15}_{110}	(397)
$RbOH.2H_2O$	c	1058.5	-2.7^{15}_{110}	(397)
RbF	c	557.9	24.3^{16}_{110}	(411)
	400	582.2	N	(414)
$RbF.\frac{1}{4}H_2O$	c	661.6	15.7^{15}_{110}	(413)
$RbF.1\frac{1}{4}H_2O$	c	1014.0	-2.6^{15}_{110}	(413)
$RbHF_2$	c	919.4	-22.2^{15}_{110}	(414)
	400	897.3	N	(414)
RbCl	c	439.3	-17.7^{21}_{400}	(399, 493, 1073)
	400	420.7	N; analogy	
RbBr	c	402	-24.9^{15}_{110}	(411)
	400	375	ions	
$RbBr_3$	c	381	dissoc.*	(336*)
$RbBrCl_2$	c	437	dissoc.*	(336*)
$RbBr_2Cl$	c	421	dissoc.*	(336*)
RbI	c	338	-27.2^{15}_{110}	(411)
	aq.	311	ions	
RbI_3	c	285	dissoc.*	(336†)
$RbICl_2$	c	421	dissoc.*	(336†)
$RbIBr_2$	c	364	dissoc.*	(336†)
Rb_2S	c	367	103	(856)
	aq.	470	N	(856)
Rb_2SO_4	c	1422.8	-27.9^{18}_{220}	(399)
	440	1395.5	N	(399)
$RbHSO_4$	c	1147.1	-15.6^{15}_{220}	(399)
	330	1131.3	N	(399)
$RbI.4SO_2$	c	1666	dissoc.*	(342*)
$RbNO_{3(II)}$	c	500.6	-36.7^{21}_{400}	(493)
$RbNO_{3(I)}$	c		Tr.; $4.4^{164}_{(II)}$	(234)
	200	464.5	ions	
$RbBr.3NH_3$	c	629	dissoc.*	(187†)
$RbI.6NH_3$	c	801	dissoc.*	(187†)
Rb_2CO_3	c	1146	36.6	(402)
	aq.	1183	N	(402)
	sat.	1179.0	dil.	(405)
$Rb_2CO_3.H_2O$	c	1457	12.0^{15}_{110}	(405)
$Rb_2CO_3.1\frac{1}{2}H_2O$	c	1612	-0.8^{15}_{110}	(405)
$Rb_2CO_3.3\frac{1}{2}H_2O$	c	2199	-15.1^{15}_{110}	(405)
$RbHCO_3$	c	965	-19.8^{15}_{110}	(264,† 406)
	aq.	945	N	(405)
$4Rb_2CO_3.CO_2.5\frac{1}{2}H_2O$	c	6758	−32.3	(407)
RbCNS	c	238	−6e	analogy
	aq.	179	ions	
$2RbCNS.SO_2$	c	571	dissoc.*	(342*)
$2RbCl.ThCl_4$	c	2401	81	(268)
$2RbCl.ThCl_4.9H_2O$	c	5046	11	(268)
$4RbCl.ThCl_4$	c	3208	115	(268)
$2RbCl.CuCl_2$	c	1116	-12.8^{18}_{800}	(226)
$2RbCl.CuCl_2.2H_2O$	c	1720	-44.5^{18}_{800}	(226)
Cesium[b]				
Cs	c	0	Def.	
Cs^+	∞	260	CsCl	
Cs_2O	c	344	348^{18}_{600}	(44, 853, 854)
Cs_2O_4	c	576	$138^{15}_{H_2SO_4(2400)}$	(409)
$CsOH_{(\beta)}$	c	419.6	68.7^{15}_{110}	(42, 397)
$CsOH_{(\alpha)}$	c		Tr.; $7.4^{223}_{(\beta)}$	(515)
	400	488.9	$Cs + H_2O$	(44, 854)
	sat.	476	dil.	(408)
$CsOH.H_2O$	c	756.4	18.0^{15}_{110}	(397)
CsF	c	552.3	35.0^{15}_{110}	(401)
	400	587.5	ions	
$CsF.\frac{1}{2}H_2O$	c	760.5	17.7^{15}_{110}	(413)
$CsF.1\frac{1}{2}H_2O$	c	1012.6	4.1^{15}_{110}	(413)
$CsHF_2$	c	918.1	−15.6	(414)
	aq.	902.5	N	(414)
$CsCl_{(\beta)}$	c	445.6	-19.2^{19}_{220}	(42, 399, 493)
$CsCl_{(\alpha)}$	c		Tr.; $5.6_{(\beta)}$	(1073)
	gas	243	→ c*	(366)
	400	425.89	N	(42)
	200	426.15	dil.	(867c)
	100	426.62	dil.	
	50	427.40	dil.	
CsBr	c	407.9	-28.2^{15}_{110}	(399)
	aq.	380	ions	
$CsBr_3$	c	388	dissoc.*	(336*)
$CsBrCl_2$	c	442	dissoc.*	(336*)
$CsBr_2Cl$	c	425	dissoc.*	(336*)
CsI	c	350.5	-34.5^{15}_{110}	(399)
	aq.	317	ions	
CsI_3	c	300	dissoc.*	(336*)
$CsICl_2$	c	428	dissoc.*	(336*)
$CsIBr_2$	c	372	dissoc.*	(336*)
CsI_2Br	c	357	dissoc.*	(336*)
Cs_2S	c	366	114	(856)
	aq.	480	N	(856)
Cs_2SO_4	c	1427	-20.8^{15}_{220}	(399)
	440	1406	N	(399)
$CsHSO_4$	c	1152	-15.6^{15}_{220}	(399)
	220	1137	N	(399)
$CsI.4SO_2$	c	1693	dissoc.*	(342*)
$CsNO_{3(II)}$	c	509.7	-40.2^{20}_{400}	(493)
$CsNO_{3(I)}$	c		Tr.; $3.5^{153}_{(II)}$	(234*)
	400	469.50	ions	
	200	471.08	dil.	(867c)
	100	472.22	dil.	
	60	473.49	dil.	
Cs_2CO_3	c	1143.1	49.5^{15}_{220}	(402)
	aq.	1193.6	N	(402)
	sat.	1192.8	dil.	(402)
$Cs_2CO_3.3\frac{1}{2}H_2O$	c	2209.3	-15.1^{15}_{220}	(405)
$CsHCO_3$	c	968	-18^{15}_{220}	(262,* 406)
	aq.	950	N	(406)
$6Cs_2CO_3.CO_2.11H_2O$	c	10 760	−34.4	(407)
$6Cs_2CO_3.CO_2.18\frac{1}{2}H_2O$	c	12 770	−108.0	(407)
Cs_2ThCl_6	c	2357	136	(268)
$Cs_2ThCl_6.8H_2O$	c	4770	10	(268)
Cs_4ThCl_8	c	3261	83	(268)
$2CsCl.CuCl_2$	c	1134	-19.7^{18}_{800}	(226)
$2CsCl.CuCl_2.2H_2O$	c	1727	-41.0^{12}_{800}	(226)
$CsLiICl_{(melt)}$	c		1.6_{240}	(45)
$CsNaICl_{(melt)}$	c		-38.2_{240}	(45)
CsKICl	c		-50.2_{440}	(45)

[a] RbCl + KCl; heat of solution, (959). $Rb_2SO_4.CuSO_4.6H_2O$, heat of dissociation (262). Rb_2SO_4, double salts with $CdSO_4$, $MnSO_4$, $CoSO_4$, $ZnSO_4$, $NiSO_4$, $MgSO_4$, heat of dissociation of hydrate (262).

[b] $CsCNS.\frac{1}{2}SO_2$, heat of dissociation (342). $Cs_2SO_4.CuSO_4.6H_2O$, heat of dissociation (261, 262). $Cs_2SO_4.X\,SO_4.6H_2O$, X = Cd, Mn, Co, Zn, Ni, Mg; heats of dissociation (262). $CsAuCl_4$, heat of dissociation (780.5).

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(250) Brönsted, *9*, **20**: 81; 14. (250.5) Brown, *4*, **83**: 987; 03. (251) Brühl, *25*, **28**: 2847; 95. (252) Bruni and Levi, *36*, **45 II**: 161; 15. (253) Bruni and Levi, *36*, **47 I**: 259; 17. (254) Büchner and Prins, *7*, **81**: 113; 12. (255) Bussy and Buignet, *6*, **3**: 231; 64. (256) Cady, *50*, **3**: 127; 99. (257) Cailletet and Bordet, *34*, **95**: 58; 82. (258) Campbell, *140*, **59**: 211; 01. (259) Campbell and Hartman, *1*, **20**: 690; 98.

(260) Carlton-Sutton, *5*, **93**: 155; 17. (261) Caven and Ferguson, *4*, **121**: 1406; 22. (262) Caven and Ferguson, *4*, **125**: 1307; 24. (263) Caven and Sand, *4*, **99**: 1359; 11. (264) Caven and Sand, *4*, **105**: 2752; 14. (265) Chappuis, *6*, **15**: 498; 88. (266) Chassevent, *34*, **179**: 44; 24. (267) Chaudron, *6*, **16**: 221; 21. (268) Chauvenet, *6*, **23**: 425; 11. (269) Chauvenet, *6*, **28**: 536; 13.

(270) Chauvenet, *34*, **164**: 630; 17. (271) Chauvenet, *34*, **164**: 816; 17. (272) Chauvenet, *34*, **165**: 25; 17. (273) Chauvenet and Nicolle, *34*, **166**: 781; 18. (274) Cheltzov, *34*, **100**: 1458; 85. (275) Chernobaev, *74*, **21**: 729; 05. (276) Chernobaev and Vologdine, *34*, **154**: 206; 12. (277) Chrétien and Guinchant, *34*, **137**: 65; 03. (278) Chroustchoff, *6*, **13**: 443; 88. (279) Chroustchoff and Martinoff, *6*, **11**: 234; 87.

(280) Clark, *12*, **7**: 1; 24. (281) Cohen, *7*, **14**: 53; 94. (282) Cohen, *7*, **30**: 623; 99. (283) Cohen and Bruins, *64P*, **20**: 587; 17. (284) Cohen and Bruins, *64V*, **25**: 1277; 17. (285) Cohen and Helderman, *64P*, **17**: 1050; 15. (286) Cohen and Helderman, *7*, **113**: 145; 24. (287) Cohen and Inouye, *7*, **75**: 219; 10. (288) Cohen and Strengers, *7*, **52**: 129; 05. (289) Cohen and Visser, *7*, **36**: 517; 01.

(290) Cohen, Helderman and Moesveld, *7*, **96**: 259; 20. (291) Cohen, Hetterschij and Moesveld, *7*, **94**: 210; 20. (292) Cohen, Kruisheer and Moesveld, *7*, **96**: 437; 20. (293) Colson, *6*, **12**: 433; 07. (294) Colson, *34*, **161**: 414; 15. (295) Colson, *34*, **161**: 458; 15. (296) de Coninck, *34*, **131**: 1219; 00. (297) Copaux, *93*, **74**: 351; 12. (298) Copaux and Philips, *54*, **171**: 630; 20. (299) Copaux and Philips, *34*, **176**: 579; 23. (299.5) Copeland and Bichowsky, *0*.

(300) Cottrell, *50*, **2**: 492; 98. (301) Crut, *B20*. (302) Damiens, *14*, **18**: 282; 22. (303) Daniels and Bright, *1*, **42**: 1131; 20. (304) Darzens, *34*, **154**: 1232; 12. (305) Debray, *34*, **86**: 513; 78. (306) Delépine, *27*, **29**: 1166; 03.

(307) Delépine and Hallopeau, *34*, **129**: 600; 99. (308) Despretz, *6*, **37**: 180; 1928 (309) van Deventer and Conen, *514*, **18**: 87; 94.

(310) van Deventer and Reicher, *7*, **5**: 177; 90. (311) van Deventer and Reicher, *514*, **17**: 93; 91. (312, 313) van Deventer and van der Stadt, *7*, **9**: 43; 92. (313.5) Dieke and Hopfield, *96*, **40**: 299; 26. (314) Ditte, *34*, **70**: 935; 70. (315) Ditte, *34*, **73**: 858; 71. **73**: 109; 71. (316) Ditte, *34*, **85**: 1103; 77. (317) Dodd, *1*, **43**: 1579; 20. (318) Doerinckel, *93*, **66**: 20; 10. (319) Dolch, *9*, **26**: 455; 20.

(320) Donnan and Hope, *85*, **5**: 244; 09. (321) Drägert, *Diss.*, Berlin, 1914. (322) Dulong, *34*, **7**: 871; 38. (323) Dulong, *6*, **8**: 180; 43. (324, 325) Dunnington and Hoggard, *11*, **22**: 207; 99. (326) Dupre and Page, *8*, **5 Ergänzb.**: 221; 70. (327) Eastman, *1*, **44**: 975; 22. (328) Edgar and Cannon, *1*, **44**: 2842; 22. (329) Egertou, *3*, **33**: 33; 17.

(330) Ellingson, *1*, **37**: 699; 15. (331) Emery and Benedict, *181*, **28**: 301; 11. (332) Ephraim, *25*, **45**: 1322; 12. (333) Ephraim, *25*, **46**: 3103; 13. (334) Ephraim, *7*, **81**: 513; 13. (335) Ephraim, *7*, **83**: 196; 13. (336) Ephraim, *25*, **50**: 1069; 17. (337) Ephraim, *25*, **51**: 706; 18. (338) Ephraim, *25*, **51**: 241; 19. (339) Ephraim and Bolle, *25*, **48**: 638; 15.

(340) Ephraim and Bolle, *25*, **48**: 1770; 15. (341) Ephraim and Jahnsen, *25*, **48**: 41; 15. (342) Ephraim and Kornblum, *25*, **49**: 2007; 16. (343) Ephraim and Millmann, *25*, **50**: 529; 17. (344) Estreicher, *165*, **3**: 183; 04. (345) Estreicher and Schnerr, *165*, **7A**: 345; 10. (346) Eucken, *88*, **13**: 18; 16. (347) Eucken, *13*, **440**: 111; 24. (348) Eucken and Karwat, *7*, **114**: 467; 24. (349) Ewald, *8*, **44**: 1213; 14.

(350) Fabre, *6*, **10**: 472; 87. (351) Fabre, *6*, **14**: 110; 88. (352) Fancon, *6*, **19**: 70; 10. (353) Favre, *in B78*. (354) Favre, *49*, **34**: 311; 53. (355) Favre, *34*, **77**: 101; 73. (356) Favre, *34*, **77**: 649; 73. (357) Favre, *34*, **78**: 1257; 74. (358) Favre and Quaillard, *34*, **80**: 1150; 60. (358.1) Favre and Silbermann, *34*, **33**: 411; 46. (358.5) Favre and Silbermann, *6*, **34**: 357; 52. (359) Favre and Silbermann, *6*, **37**: 406; 53.

(360) Favre and Valson, *34*, **73**: 1144; 71. (360.5) Favre and Valson, *34*, **77**: 577; 73. (361) Favre and Valson, *34*, **77**: 802; 73. (362) Felsing, *B19*. (363) Fichter, *88*, **21**: 539; 19. (364) Fichter, *93*, **54**: 322; 07. (365) Fichter and Jenny, *37*, **5**: 448; 22. (366) Fiock and Rodebush, *1*, **48**: 2522; 26. (367) Fischer, *93*, **78**: 41; 12. (368) Fischer and Tropsch, *25*, **50**: 765; 17. (369) Fogh, *6*, **21**: 43; 90.

(370) Fogler and Rodebush, *1*, **45**: 2080; 23. (371) Foote and Saxton, *1*, **36**: 1695; 14. (372) Foote and Smith, *1*, **30**: 1344; 08. (373) de Forcrand, *6*, **3**: 129; 84. (374) de Forcrand, *6*, **3**: 187; 84. (375) de Forcrand, *6*, **3**: 242; 84. (376) de Forcrand, *34*, **101**: 318; 85. (377) de Forcrand, *34*, **108**: 59; 86. (378) de Forcrand, *6*, **11**: 277; 87. (379) de Forcrand, *34*, **110**: 681; 90.

(380) de Forcrand, *34*, **130**: 737; 95. (381) de Forcrand, *34*, **130**: 1215; 95. (382) de Forcrand, *34*, **121**: 66; 95. (383) de Forcrand, *34*, **127**: 514; 98. (384) de Forcrand, *34*, **130**: 834; 00. (385) de Forcrand, *34*, **130**: 1017; 00. (386, 387) de Forcrand, *34*, **130**: 1308; 00. (388) de Forcrand, *34*, **130**: 1465; 00. (389) de Forcrand, *34*, **130**: 1620; 00.

(390) de Forcrand, *6*, **27**: 26; 02. (391) de Forcrand, *34*, **133**: 157; 02. (392) de Forcrand, *34*, **133**: 223; 02. (393) de Forcrand, *34*, **133**: 1304; 02. (394) de Forcrand, *34*, **140**: 990; 05. (395) de Forcrand, *6*, **9**: 234; 06. (396) de Forcrand, *27*, **35**: 781; 06. (397, 398) de Forcrand, *34*, **142**: 1252; 06. (399) de Forcrand, *34*, **143**: 98; 06.

(400) de Forcrand, *6*, **15**: 433; 08. (401) de Forcrand, *34*, **145**: 217; 08. (402) de Forcrand, *34*, **145**: 511; 08. (403) de Forcrand, *34*, **145**: 802; 08. (404) de Forcrand, *34*, **147**: 165; 08. (405) de Forcrand, *34*, **149**: 97; 09. (406) de Forcrand, *34*, **149**: 719; 09. (407) de Forcrand, *34*, **149**: 825; 09. (408) de Forcrand, *34*, **149**: 1341; 09. (409) de Forcrand, *34*, **150**: 1399; 10.

(410) de Forcrand, *6*, **24**: 256; 11. (411) de Forcrand, *34*, **152**: 27; 11. (412) de Forcrand, *34*, **152**: 1073; 11. (413) de Forcrand, *34*, **153**: 1208; 11. (414) de Forcrand, *34*, **152**: 1556; 11. (415) de Forcrand, *6*, **25**: 216; 12. (416) de Forcrand, *34*, **157**: 441; 13. (417) de Forcrand, *34*, **158**: 20; 14. (418) de Forcrand, *34*, **158**: 843; 14. (419) de Forcrand, *34*, **158**: 991; 14.

(420) de Forcrand, *34*, **160**: 467; 15. (421) de Forcrand, *14*, **3**: 5; 15. (422, 423) de Forcrand, *34*, **175**: 873; 23. (423.5) de Forcrand, *34*, **152**: 609, 1191; 26. (424) de Forcrand and Fonzes-Diaçon, *6*, **26**: 247; 02. (425) de Forcrand and Tabourý, *34*, **169**: 162; 19. (426) Fox, *83*, **5**: 68; 09. (427) Franck and Hochwald, *9*, **31**: 552; 25. (428) Frankland, *3*, **32**: 182; 66. (428.1) Frost and Bichowsky, *O*. (429) Frowein, *7*, **1**: 5; 87.

(430) Frowein, *7*, **1**: 362; 87. (431) Gain, *6*, **14**: 224; 08. (432) Galt, *153*, **69**: 246; 98. (433) Garelli, *36*, **32 II**: 253; 98. (434) Gaudechon, *34*, **144**: 1419; 07. (435) Gaudechon, *6*, **23**: 145; 11. (436) Gautier, *34*, **128**: 939; 99. (437) Gay, *Diss.*, Paris, 1895. (438) Gebhart, *in* Kröner, *8*, **40**: 438; 13. (439) Gerke, *1*, **44**: 1684; 22.

(440) Germann and McIntyre, *50*, **29**: 102; 25. (441) Germann and Taylor, *1*, **43**: 1154; 25. (442) Gerth, *9*, **27**: 287; 21. (443) Getman, *1*, **39**: 1806; 17. (444) Getman and Gibbons, *11*, **43**: 124; 12. (445) Gillespie and Hall, *1*, **48**: 1207; 26. (446) Giran, *34*, **134**: 711; 02. (447) Giran, *6*, **30**: 208; 03. (448) Giran, *34*, **140**: 1704; 05. (449) Giran, *34*, **146**: 1270; 08.

(450) Giran, *3*, **14**: 565; 08. (450.5) Giran, *27*, **13**: 1049; 13. (451, 452) Gire, *34*, **174**: 1700; 22. (453) Gire, *14*, **4**: 183; 25. (454) Gire, *14*, **4**: 370; 25. (455) Gnesotto and Fabris, *24*, **70 II**: 471; 11. (456) Golblum and Stoffella, *42*, **8**: 135; 10. (457) Goldschmidt and Maarseveen, *7*, **25**: 91; 98. (458) Graham, *3*, **22**: 329; 43. (459) Graham, *3*, **24**: 401; 44. (459.5) Grassi, *49*, **8**: 170; 45.

(460) Greenwood, *5*, **83**: 483; 10. (460.5) Greenwood, *115*, **92**: 419; 11. (461) Griffiths, *62*, **186**: 261; 95. (462) Griveau, *34*, **166**: 933; 18. (463) Guinchant and Chrétien, *34*, **139**: 51, 288; 04. (464) Guntz, *6*, **3**: 5; 84. (465) Guntz, *34*, **98**: 303, 512; 84. (466) Guntz, *34*, **101**: 161; 85. (467) Guntz, *34*, **105**: 673; 87. (468) Guntz, *6*, **13**: 388; 88. (469) Guntz, *6*, **13**: 395; 88.

(470) Guntz, *34*, **112**: 1212; 91. (471) Guntz, *27*, **13**: 114; 95. (472) Guntz, *34*, **122**: 465; 96. (473) Guntz, *34*, **123**: 694; 96. (474) Guntz, *34*, **123**: 995; 96. (475) Guntz, *34*, **126**: 1866; 98. (476) Guntz, *34*, **136**: 1071; 03. (477) Guntz, *6*, **4**: 5; 05. (478) Guntz and Basset, *34*, **140**: 863; 05. (479) Guntz and Basset, *42*, **4**: 1; 06.

(480) Guntz and Benoit, *14*, **20**: 5; 23. (481) Guntz and Guntz, *14*, **2**: 101; 14. (482) Guntz and Martin, *27*, **5**: 1004; 09. (483) Guntz and Roëderer, *34*, **142**: 400; 06. (484) Haber, *B14*. p. 89. (485) Haber, *9*, **20**: 597; 14. (486) Haber, *92*, **27**: 473; 14. (487) Haber and van Oordt, *93*, **44**: 341; 05. (488) Haber and Tamaru, *9*, **21**: 191; 15. (489) Haber and Zisch, *96*, **9**: 302; 22.

(490) Hablutzel, *Thesis*, Stanford University, 1926. (491) Hackspill, *34*, **154**: 877; 12. (492) Hackspill and Grandadam, *14*, **5**: 218; 26. (493) Haigh, *1*, **34**: 1137; 12. (494) Halla, *9*, **14**: 411; 08. (495) Hammerl, *34*, **89**: 97; 79. (496, 497) Hammerl, *34*, **90**: 312; 80. (498) Hantzsch, *7*, **61**: 257; 07. (499) Hara and Shinozaki, *142*, **26**: 884; 23.

(500) Harned, *1*, **42**: 1808; 20. (501) Harned and Brumbaugh, *1*, **44**: 2729; 22. (501.5) Harrison and Perman, *83*, **23**: 1; 27. (502) Hartley and Campbell, *4*, **93**: 741; 08. (503) Hartog, *34*, **104**: 1793; 87. (504) Harvey and Schuette, *1*, **48**: 2065; 26. (505) Henderson and Stegeman, *1*, **40**: 84; 18. (506) Henglein, *96*, **12**: 245; 22. (507) Henglein, *93*, **123**: 137; 22. (508) Henning, *8*, **21**: 849; 06. (509) Henning *8*, **29**: 441; 09.

(510) Henning, *8*, **58**: 759; 19. (511) Herschkowitsch, *7*, **27**: 123; 98. (512) Herschkowitsch, *93*, **115**: 159; 21. (513) van Heteren, *93*, **42**: 129; 04. (514) Heusler, *93*, **154**: 353; 26. (515) Hevesy, *7*, **73**: 667; 10. (516) Heycock and Lamplough, *182*, **18**: 3; 12. (517) Heycock and Neville, *4*, **71**: 383; 97. (518) Higley, *1*, **26**: 613; 04. (519) Hildebrand, *1*, **34**: 246; 12.

(520) Hirsch, *78*, **20**: 57; 11. (521) Hittorf, *8*, **126**: 193; 65. (522) van't Hoff, Kenrick and Dawson, *7*, **39**: 27; 02. (523) van't Hoff, *et al.*, *7*, **45**: 257; 03. (524) Holborn, Scheel and Henning, *B63*. (525) Holsboer, *7*, **39**: 691; 02. (526) Horek, *B16*. (527) Hüttig, *93*, **123**: 31; 22. (528) Hüttig, *93*, **124**: 322; 22. (529) Hüttig and Krajewski, *93*, **141**: 133; 24.

(530) Hüttig and Kurre, *93*, **126**: 167; 23. (531) Hüttig and Martin, *93*, **125**: 269; 23. (532) Hüttig and Pohle, *93*, **138**: 1; 24. (533) Hüttig and Reuscher, *93*, **137**: 155; 24. (534) Hulett, *78*, **15**: 435; 09. (535) Hurter, *112*, **224**: 71; 77. (536) Itaka, *159*, **8**: 99; 19. (537) Isambert, *B17*. (538) Isambert, *34*, **70**: 456; 70. (539) Isambert, *34*, **86**: 968; 78.

(540) Isambert, *34*, **91**: 768; 80. (541) Isambert, *34*, **92**: 919; 81. (542) Isambert, *34*, **95**: 1355; 82. (543) Isambert, *6*, **28**: 332; 83. (544) Ishikawa, *142*, **43**: 560; 22. (545) Isnardi, *8*, **61**: 264; 20. (546) Jahn, *8*, **23**: 491; 86. (546.5) Jahn, *7*, **11**: 787; 93. (547) Jahn, *93*, **60**: 337; 08. (548) Jakowkin, *7*, **29**: 613; 99. (549) Jannek and Meyer, *93*, **83**: 51; 13.

(550) Jarry, *6*, **17**: 327; 99. (551) Jellinek and Diethelm, *93*, **124**: 203; 22. (552) Jellinek and Uloth, *7*, **119**: 161; 26. (553) Jellinek and Zakowski, *93*, **142**: 1; 25. (554) Jirsa and Diamant, *7*, **123**: 261; 26. (555) Joannis, *6*, **16**: 482; 82. (556) Joannis, *34*, **95**: 295; 82. (557) Joannis, *34*, **102**: 1161; 86. (558) Joannis, *6*, **12**: 358; 87. (559) Joannis, *6*, **7**: 5; 06.

(560) Joannis and Croizier, *34*, **118**: 1149; 94. (561) Job, *34*, **176**: 1805; 23. (562) Johnson, *7*, **65**: 36; 08. (563) Johnston, *1*, **30**: 1357; 08. (564) Johnston, *7*, **63**: 330; 08. (565) Johnston, *7*, **65**: 737; 08. (566) Joly, *34*, **100**: 447; 85. (567) Joly, *34*, **101**: 259; 86. (568) Joly, *34*, **103**: 1197; 86. (569) Joly, *34*, **104**: 1702; 87.

(570) Jones and Hartmann, *1*, **37**: 752; 15. (571) Jorissen, *7*, **74**: 308; 10. (571.5) Jorissen and van der Stadt, *52*, **51**: 102; 95. (572) Jouniaux, *34*, **129**: 883; 99. (573) Jouniaux, *42*, **1**: 609; 04. (574) Joyner, *93*, **77**: 103; 12. (575) Kailan and Jahn, *93*, **68**: 243; 10. (576) Kameyama, *43*, **10**: 249; 20. (577) Kamura, *33*, **24**: 437; 21. (578) Kendall, *50*, **13**: 736; 14. *1*, **36**: 1486; 16. (579) Keyes, *1*, **34**: 779; 12.

(580) Keyes, Gillespie and Mitsukuri, *1*, **44**: 707; 22. (581) Keyes and Hara, *1*, **44**: 479; 22. (582) King and Partington, *4*, **1926**: 925. (583) Kirschner, *7*, **79**: 245; 12. (584) Klein, *7*, **36**: 361; 01. (584.5) Knudsen, *8*, **29**: 179; 09. (585) Kohlschütter and Feitknecht, *37*, **6**: 337; 23. (586) Kohn, *96*, **3**: 143; 20. (587) Kohn and Guckel, *96*, **27**: 305; 24. (588) Kohn and Guckel, *218*, **13**: 139; 24. (589) Kohnert, *Diss.*, Berlin, 1914.

(590) Kolosovskii, *53*, **57**: 22; 25. (591) Koppel, *93*, **67**: 293; 10. (592) Koref, *93*, **66**: 73; 10. (593) Koref, *8*, **36**: 49; 11. (594) Krahmer, *9*, **26**: 97; 20. (595) Krase and Yee, *1*, **45**: 1358; 24. (596) Krauss and Geriach, *93*, **140**: 61; 24. (597) Kremers and Stevens, *1*, **45**: 614; 23. (598) Krummacher, *145*, **46**: 302; 04. (599) Kuhn, *218*, **14**: 600; 26. (599.5) Kurbatov, *7*, **43**: 104; 03.

(600) von Laar, *7*, **17**: 545; 95. (601) Laksonen, *138*, **1**: No. 12; 21. (602) Lamb and Simmons, *1*, **43**: 2188; 21. (603) Landis, *56*, **14**: 87; 16. (604)

Lange and Dürr, *7*, **121**: 361; 26. (605) Langmuir, *1*, **34**: 860; 12. (606) Langmuir, *1*, **37**: 417; 15. (607) Langmuir and Mackay, *1*, **36**: 1708; 14. (608) Lashchenko, *53*, **42**: 1604; 10. (609) Lashchenko, *118*, **2 II**: 8; 13.
(610) Lashchenko, *53*, **46**: 311; 14. (611) Lashchenko, *118*, **3**: 59; 14. (612) Lashchenko, *53*, **48**: 793; 16. (613) Latimer, *1*, **44**: 90; 22. (614) Lebeau, *6*, **6**: 422; 05. (615) Le Chatelier, *34*, **99**: 1074; 84. (616) Le Chatelier, *34*, **115**: 654; 92. (617) Le Chatelier, *34*, **116**: 390; 93. (618) Le Chatelier, *34*, **120**: 623; 96. (619) Le Chatelier, *34*, **122**: 80; 96.
(620) Le Chatelier, *27*, **17**: 791; 97. (621) Lecher, *75*, **78 II**: 711; 78. (622) Lecocq, *25*, **25**: 72; 11. (623) Lehtonen, *138*, **1**: No. 13; 21. (624) Lemoine, *6*, **30**: 289; 93. (625) Lemoine, *34*, **125**: 603; 97. (626) Lemoult, *6*, **16**: 338; 99. (627) Lemoult, *6*, **10**: 395; 07. (628) Lemoult, *34*, **145**: 374; 07. (629) Lerner-Steinberg, *7*, **122**: 121; 26.
(630) Lescoeur, *6*, **21**: 511; 90. (631) Lescoeur, *6*, **21**: 524; 90. (632) Lescoeur, *6*, **25**: 423; 92. (633) Lescoeur, *6*, **2**: 78; 94. (634) Levalt-Ezerskii, *53*, **44**: 665; 12. (635) Lewis, *1*, **28**: 158; 06. (636) Lewis, *1*, **46**: 2027; 24. (637) Lewis and Brighton, *1*, **39**: 1906; 17. (638) Lewis and Keyes, *1*, **34**: 119; 12. (639) Lewis and Keyes, *1*, **35**: 340; 13.
(640) Lewis and Kraus, *1*, **32**: 1459; 10. (641) Lewis and Lacey, *1*, **37**: 1976; 15. (641.1) Lewis and Randall, *Thermodynamics and the Free Energy of Chemical Substances*. New York, McGraw-Hill, 1923. (642) Lewis and Randall, *1*, **33**: 476; 11. (643) Lewis and Randall, *1*, **36**: 1969; 14. (644) von Liempt, *93*, **120**: 267; 22. (645) von Liempt, *93*, **129**: 263; 23. (646) Lindner, *57*, **33**: 613; 12. (647) Lindner, *75*, **121 IIb**: 261; 12. (648) Linhart, *1*, **40**: 158; 18. (649) Littleton, *135*, **74**: 289; 96.
(650) Lloyd, *50*, **12**: 398; 08. (650.5) Louguinine, *6*, **13**: 289, 334; 98. (651) Maass and Hiebert, *1*, **46**: 2693; 24. (652) MacInnes and Braham, *1*, **39**: 2110; 17. (653) Magie, *2*, **35**: 265; 12. (654) Magnus and Braner, *93*, **151**: 140; 26. (655) Magnus and Mannheimer, *7*, **121**: 267; 26. (656) Magnusson, *50*, **11**: 21; 07. (657) Maier, *1*, **48**: 356; 26. (658) Maier, Parks and Anderson, *1*, **48**: 2564; 26. (659) Maier and Ralston, *1*, **48**: 364; 26.
(660) Mallard and Le Chatelier, *34*, **97**: 102; 83. (661) Manchot, *93*, **140**: 22; 24. (662) Mannheimer, *510*, **37**: 47; 24. (663) Marc and Šimek, *93*, **82**: 17; 13. (664) Marchal, *34*, **175**: 270; 22. (665) Marchal, *34*, **176**: 299; 23. (665.5) Marchal, *42*, **22**: 413, 493; 25. (666) Marignac, *18*, **42**: 209; 71. (667) Marketos, *34*, **155**: 210; 12. (667.5) Marshall, *3*, **43**: 27; 97. (668) Marshall and Bruzs, *50*, **29**: 1184; 25. (668.5) Marshall and Ramsay, *3*, **41**: 38; 96. (669) Martin and Metz, *93*, **127**: 83; 23.
(670) Mathews, *1*, **33**: 1291; 11. (671) Mathews and Germann, *50*, **15**: 73; 11. (672) Mathias, *6*, **21**: 69; 90. (673) Matignon, *34*, **124**: 1026; 97. (674) Matignon, *6*, **8**: 243; 06. (675) Matignon, *6*, **8**: 402; 06. (676) Matignon, *6*, **8**: 426; 06. (677) Matignon, *6*, **8**: 433; 06. (678) Matignon, *6*, **10**: 104; 07. (679) Matignon, *6*, **14**: 5; 08.
(680) Matignon, *34*, **154**: 1351; 12. (681) Matignon, *27*, **13**: 791; 13. (682) Matignon, *136*, **38**: 894; 14. (683) Matignon, *27*, **35**: 29; 24. (684) Matignon and Delépine, *6*, **10**: 130; 07. (685) Matignon and Fréjacques, *27*, **31**: 307, 394; 22. (686) Matignon and Marchal, *27*, **27**: 254: 20. (687) Matignon and Marchal, *27*, **39**: 167; 26. (688) Matignon and Meyer, *34*, **166**: 686; 18. (689) Matignon and Trannoy, *34*, **140**: 141; 05.
(690) Matignon and Trannoy, *6*, **8**: 284; 06. (691) Maxwell and Hayes, *1*, **48**: 584; 26. (692) Mayer, *7*, **113**: 220; 24. (693) Mazzotto, *23*, **17**: 111; 81. (694) Mees, *Diss.*, Utrecht, 1916. (695) Melcher, *1*, **32**: 50; 10. (696) Metzner, *6*, **15**: 203; 98. (697) Meuthen, *139*, **10**: 1; 12. (698) Meyer, *34*, **148**: 346; 09. (699) Meyer and Rötger, *93*, **57**: 104; 08.
(700) Mielenz and Wartenberg, *93*, **116**: 267; 21. (701) Mitchell, *4*, **123**: 1055; 23. (702) Mitscherlich, *8*, **88**: 328; 52. (703) Mixter, *12*, **12**: 347; 01. (704) Mixter, *12*, **16**: 214; 03. (705) Mixter, *12*, **19**: 434; 05. (706) Mixter, *12*, **24**: 130; 07. (707) Mixter, *12*, **26**: 125; 08. (708) Mixter, *12*, **27**: 229; 09. (709) Mixter, *12*, **27**: 393; 09.
(710) Mixter, *12*, **28**: 103; 09. (711) Mixter, *12*, **29**: 488; 10. (712) Mixter, *12*, **30**: 193; 10. (713) Mixter, *12*, **32**: 202; 11. (714) Mixter, *12*, **34**: 141; 12. (715) Mixter, *12*, **36**: 55; 13. (716) Mixter, *12*, **39**: 295; 15. (717) Mixter, *12*, **40**: 23; 15. (718) Moers, *93*, **113**: 179; 20. (719) Moissan, *27*, **21**: 928; 99.
(720) Moldenhauer, *93*, **51**: 369; 06. (721) Moldenhauer and Roll-Hansen, *93*, **82**: 130; 13. (722) Moles, *7*, **90**: 70; 15. (723) Moles and Crespi, *7*, **100**: 337; 22. (724) Moles and Gomez, *7*, **80**: 513; 12. (725) Moles and Gonzalez, *132*, **21**: 204; 23. (726) Mond, Ramsay and Shields, *62*, **191**: 105; 98. (727) Mond, Ramsay and Shields, *7*, **25**: 666; 98. (728) Mondain-Monval, *34*, **176**: 301; 23. (729) Mondain-Monval, *34*, **176**: 889; 23.
(730) Mondain-Monval, *34*, **182**: 58; 26. (730.1) Mondain-Monval, *34*, **182**: 1465; 26. (730.5) Moose and Parr, *1*, **46**: 2656; 24. (731) Morgan and Benson, *1*, **29**: 1168; 07. (732) Morgan and Owen, *1*, **29**: 1439; 07. (733) Morges, *34*, **86**: 1443; 78. (734) Mortimer and Pearce, *50*, **21**: 275; 17. (735) Moser and Herzner, *57*, **44**: 115; 23. (736) Moutier, *34*, **79**: 1242; 74. (737) Müller, *7*, **86**: 177; 13. (738) Müller, *7*, **123**: 1; 26. (739) Mulder and Meulen, *70*, **1**: 73; 80.
(740) Mulert, *93*, **75**: 198; 12. (741) Muller, *27*, **44**: 608; 85. (742) Muller, *6*, **15**: 517; 88. (743) Muller, *6*, **20**: 384; 00. (744) Muller, *6*, **9**: 263; 06. (745) Muller, *27*, **13**: 1053; 13. (746) Muller, *27*, **15**: 491; 14. (747) Muller, *27*, **15**: 494; 14. (748) Muller, *27*, **23**: 8; 18. (749) Muller-Erzbach, *7*, **19**: 135; 96.
(750) Muller-Erzbach, *7*, **21**: 545; 96. (751) Muthmann and Beck, *13*, **331**: 46; 04. (752) Muthmann and Weiss, *13*, **331**: 1; 04. (753) Nacken, *146*, **11**: 245, 257; 22. (754) Nernst, *7*, **2**: 23; 88. (755) Nernst, *93*, **49**: 213; 06. (756) Neumann, *93*, **145**: 193; 25. (757) Neumann and Bergve, *9*, **21**: 152; 15. (758) Neumann and Müller, *92*, **38**: 193; 25. (759) Noyes and Chow, *1*, **40**: 739; 18.
(760) Noyes and Ellis, *1*, **39**: 2532; 17. (761) Noyes and Sammet, *7*, **43**: 513; 03. (762) Noyes and Tuley, *1*, **47**: 1336; 25. (763) Noyes and Wobbe, *1*, **48**: 1882; 26. (764) Nydegger, *33*, **29**: 1141; 23. (765) Ochi, *142*, **26**: 1; 23. (766) Ogier, *34*, **87**: 210; 78. (767) Ogier, *34*, **89**: 705; 79. (768) Ogier, *6*, **20**: 5; 80. (769) Ogier, *34*, **92**: 83; 81.
(770) Ogier, *34*, **92**: 922; 81. (771) Ogier, *34*, **94**: 82; 82. (772) Ogier, *34*, **96**: 646; 83. (773) Osborne and Van Dusen, *51A*, **14**: 439; 18. (774) Osmond, *34*, **103**: 743, 1135; 86. (775) Osmond, *54*, **113**: 474; 91. (776) Ossipoff, *6*, **20**: 371; 90. (777) Ostwald, *52*, **25**: 1; 82. (778) Parks, *1*, **47**: 338; 25. (779) Parravano and Cesaris, *36*, **47 I**: 144; 17.
(780) Parravano and Malquori, *36*, **56**: 3; 26. (781) Partington and Huntingford, *4*, **123**: 160; 23. (782) Paterno and Mazzucchelli, *36*, **50 I**: 30; 20. (783) Pearce and Farr, *50*, **18**: 729; 14. (784) Pease and Cook, *1*, **48**: 1199; 26. (785) Péchard, *6*, **28**: 537; 93. (785.5) Pélabon, *7*, **26**: 659; 98. (786) Pélabon, *6*, **25**: 365; 02. (787) Pellaton, *42*, **13**: 426; 15. (788) Perman and Atkinson, *7*, **33**: 215; 00. (789) Perman and Atkinson, *7*, **33**: 577; 00. (789.5) Perman and Lovett, *83*, **22**: 1; 26.
(790) Perrin, *8*, **11**: 5; 19. (791) Perry and Porter, *1*, **48**: 229; 26. (792) Person, *6*, **21**: 295; 47. (792.5) Person, *8*, **70**: 302, 386; 47. (793) Petersen, *7*, **4**: 383; 89. (794) Petersen, *7*, **5**: 259; 90. (795) Petersen, *7*, **8**: 601; 91. (796) Petersen, *52*, **46**: 328; 92. (797) Petersen, *7*, **11**: 174; 93. (798) Petit, *27*, **37**: 615; 25. (799) Petterson, *Diss.*, Upsala, 1879: 36.
(800) Petterson, *52*, **24**: 293; 81. (801) Pfaundler, *25*, **4**: 773; 71. (802) Pfaundler, *75*, **64**: 340; 71. (803) Pfaundler, *76*, **71 II**: 155; 75. (804) Pickering, *4*, **45**: 686; 84. (805) Pickering, *4*, **47**: 98; 85. (806) Pickering, *4*, **47**: 100; 85. (807) Pickering, *4*, **49**: 260; 86. (808) Pickering, *4*, **49**: 1; 86. (809) Pickering, *4*, **51**: 75; 87.
(810) Pickering, *4*, **51**: 290; 87. (811) Pickering, *4*, **53**: 865; 88. (812) Pickering, *4*, **57**: 64; 90. (813) Pickering, *5*, **49**: 11; 90. (814) Pickering, *4*, **99**: 800; 11. (815) Pigeon, *34*, **110**: 77; 90. (816) Pigeon, *6*, **2**: 433; 94. (817) Piloty and Steinbock, *25*, **25**: 3101; 02. (818) Pionchon, *34*, **103**: 1122; 86. (819) Pionchon, *34*, **106**: 1344; 88.
(820) Pissarjewsky, *93*, **24**: 108; 00. (821) Pissarjewsky, *7*, **40**: 368; 02. (822) Pissarjewsky, *53*, **35**: 1204; 03. (823) Pollizer, *93*, **64**: 121; 09. (824) Pollok, *4*, **85**: 603; 04. (825) Potter, *78*, **11**: 259; 07. (826) Pratolongo, *22*, **22 II**: 716; 13. (827) Pratt, *143*, **185**: 663; 18. (828) Prescott, *1*, **48**: 2534; 26. (829, 830) Preuner and Brockmöller, *7*, **81**: 129; 12.
(831) Preuner and Schupp, *7*, **68**: 219; 09. (832, 833) *See* (463). (834) Raabe, *70*, **1**: 158; 82. (835) Ramsay, *7*, **5**: 221; 90. (836) Ramsay and Young, *4*, **49**: 453; 86. (837) Randall and Bisson, *1*, **42**: 347; 20. (838) Raoult, *6*, **2**: 66; 84. (839) Ray, *5*, **101**: 509; 22.
(840) von Rechenberg, *52*, **19**: 143; 79. (841) Recoura, *6*, **10**: 5; 87. (842) Recoura, *34*, **110**: 1029; 89. (843) Recoura, *6*, **4**: 494; 95. (844) Recoura, *34*, **148**: 1105; 09. (845) Regnault, *6*, **8**: 19; 43. (846) Regnault, *6*, **26**: 268; 49. (847) Regnault, *151*, **26**: 535; 62. (848) Regnault, *6*, **24**: 375; 71. (849) Reicher and van Deventer, *7*, **5**: 559; 90.
(850) Reinders and Goudriaan, *93*, **126**: 85; 23. (851) Reinders and Hamburger, *93*, **89**: 71; 14. (852) Remy and Köhn, *93*, **137**: 365; 24. (853) Rengade, *34*, **145**: 236; 07. (854) Rengade, *6*, **14**: 540; 08. (855) Rengade and Costeanu, *27*, **15**: 717; 14. (856) Rengade and Costeanu, *34*, **158**: 946; 14. (857) Ribalquine, *134*, **34**: 165; 91. (858) Richards and Burgess, *1*, **32**: 431; 10. (859) Richards and Conant, *1*, **44**: 601; 22.
(860) Richards and Daniels, *1*, **41**: 1732; 19. (861) Richards and Davis, *1*, **42**: 1599; 20. (862) Richards and Garrod-Thomas, *7*, **72**: 165; 10. (863) Richards and Lewis, *65*, **34**: 87; 98. (864, 865) Richards and Mathews, *65*, **46**: 512; 11. *1*, **33**: 863; 11. (866) Richards and Rowe, *1*, **42**: 1621; 20. (867) Richards and Rowe, *1*, **43**: 770; 21. (868) Richards and Rowe, *1*, **44**: 684; 22. (869) Richards, Rowe and Burgess, *1*, **32**: 1176; 10.
(870) Richards and Smyth, *1*, **45**: 1455; 23. (871) Richards and Tamaru, *1*, **44**: 1060; 22. (872) Richards and Thorvaldson, *1*, **44**: 1051; 22. (873) Richards and Wilson, *7*, **72**: 129; 10. (874) Roberts and Smyth, *1*, **43**: 1061; 21. (875) Rodebush and De Vries, *1*, **47**: 2488; 25. (876) Rodebush and Dixon, *1*, **47**: 1036; 25. (877) Rogers, *12*, **43**: 301; 92. (878) Rolla, *22*, **21**: 278; 12. (879) Rolla, *59*, **9**: 5, 384; 15.
(880) Rolla and Accame, *22*, **22 II**: 109; 13. (881) Roos, *93*, **94**: 329; 16. (882) Roozeboom, *70*, **3**: 73; 84. (883) Roozeboom, *7*, **2**: 449; 88. (884) Roozeboom, *7*, **4**: 31; 89. (885) Roth, *9*, **21**: 1; 15. (886) Roth, *9*, **26**: 288; 20. (887) Roth and Wallasch, *25*, **46**: 896; 13. (888) Rothmund, *B13*, p. 391. (889) Rudolphi, *7*, **17**: 277; 95.
(890) Rümelin, *7*, **58**: 449; 07. (891) Ruff and Friedrich, *93*, **89**: 279; 14. (892) Ruff and Gersten, *25*, **45**: 63; 12. (893) Ruff and Gersten, *25*, **46**: 394; 13. (894) Ruff and Gersten, *25*, **46**: 400; 13. (894.5) Ruff and Josephy, *93*, **153**: 17; 26. (895) Ruff and Martin, *22*, **25**: 39; 12. (896) Rushton and Daniels, *1*, **48**: 384; 26. (897) Sabatier, *6*, **22**: 5; 81. (898) Sabatier, *34*, **93**: 56; 81. (899) Sabatier, *34*, **103**: 267; 86.

(900) Sabatier, *87*, **1**: 88; 89. (901) Sabatier, *34*, **118**: 980; 94. (902) Sabatier, *34*, **126**: 301; 97. (903) Sainte-Claire Deville and Hautefeuille, *34*, **69**: 152; 69. (904) Sammet, *7*, **53**: 641; 05. (904.5) Schall, *25*, **17**: 2199; 84. (905) Scheffer, *64V*, **24**: 1513; 16. (906, 908) Schenck, Semiller and Falcke, *25*, **40**: 1704; 07. (907) Schenck and Borkenstein, *93*, **142**: 143; 25. (909) Scholz, *8*, **45**: 193; 92.

(910) Schottky, *7*, **64**: 415; 08. (911) Schreber, *7*, **24**: 651; 97. (912) Schreiner and Grimnes, *93*, **110**: 311; 20. (913) Schreiner and Seljesaeter, *93*, **137**: 389; 24. (914) Schuhmann, *1*, **46**: 1444; 24. (915) Schuhmann, *1*, **47**: 356; 25. (915.5) Schüler and Wolf, *96*, **33**: 42; 25. **35**: 477; 26. (916) Schuller and Wartha, *8*, **2**: 359; 77. (917) Schwarz and Sturm, *25*, **47**: 1730; 14. (918) Sénéchal, *34*, **156**: 552; 13. (919) Sieverts and Gotta, *9*, **32**: 105; 26.

(920) Siggel, *9*, **19**: 340; 13. (921) Sill, *1*, **38**: 2632; 16. (922) Simon, *8*, **68**: 241; 22. (923) Simons and Hildebrand, *1*, **46**: 2183; 24. (924) Skrabal, *9*, **17**: 665; 11. (925) Skrabal and Buchta, *57*, **35**: 697; 14. (925.1) Smellie, *54*, **42**: 466; 23. (926) Smith, *2*, **34**: 173; 11. (927) Smith and Ball, *1*, **39**: 179; 17. (928) Smith and Braley, *1*, **39**: 1545; 17. (929) Smith and Lombard, *1*, **37**: 38; 15.

(930) Smith, Stearn and Schneider, *1*, **42**: 32; 20. (931) Smith and Woods, *1*, **45**: 2632; 23. (932) Smits and Schoenmaker, *4*, **125**: 2554; 24. (933) Somermeier, *2*, **1**: 141; 13. (934) Stackelberg, *7*, **26**: 533; 98. (935) Stahlberg, *60*, **17**: 57; 14. (936) Stansfield, *140*, **56**: 169; 99. (937) Starck and Bodenstein, *9*, **16**: 961; 10. (938) Stearn and Smith, *1*, **42**: 18; 20. (939) Stegmüller, *9*, **16**: 85; 10.

(940) von Steinwehr, *7*, **38**: 185; 03. (941) von Steinwehr, *7*, **88**: 229; 14. (941.1) Stelzner, *Diss.*, Erlangen, 1901. (942) Stiles and Felsing, *1*, **48**: 1543; 26. (943) Stock, Gibson and Stamm, *25*, **45**: 3527; 12. (944) Stock, Siecke and Pohland, *25*, **57**: 719; 24. (945) Stock and Wrede, *25*, **40**: 2923; 07. (946) Stock and Wrede, *25*, **41**: 540; 08. (947) Stohmann, *52*, **19**: 115; 79. (948) Stohmann, Kleber and Langbein, *52*, **40**: 202; 89. (949) Stohmann, Kleber and Langbein, *52*, **40**: 341; 89.

(950) Stohmann and Langbein, *52*, **44**: 336; 91. (951) Stortenbeker, *7*, **10**: 183; 92. (952) Strombeck, *143*, **131**: 71, 470; 91. (953) Sudborough and Millar, *4*, **59**: 73; 91. (954) Swietoslawski, *7*, **72**: 49; 10. (955) Tamaru, *142*, **35**: 81; 16. (956) Tammann, *8*, **68**: 629; 99. (957) Tammann, *B57*: p. 232. (958) Tammann and Krige, *93*, **146**: 179; 25. (959) Tammann and Krings, *93*, **130**: 229; 23.

(960) Tammann and Ohler, *93*, **135**: 118; 24. (961) Tananaev, *7*, **114**: 49; 24. (962) Tanatar, *53*, **23**: 243; 91. (963) Tanatar, *53*, **25**: 97; 93. (964) Tassilly, *34*, **122**: 82; 96. (965) Tassilly, *34*, **122**: 812; 96. (966) Tassilly, *6*, **17**: 38; 99. (967) Taylor, *1*, **38**: 2295; 16. (968) Taylor and Anderson, *1*, **43**: 2014; 21. (969) Taylor and Perrott, *1*, **43**: 484; 21.

(970) von Than, *25*, **10**: 947; 77. (971) von Than, *8*, **13**: 84; 81. (972) Thomas, *6*, **11**: 204; 07. (973) Thompson and Lombard, *33*, **8**: 617, 682; 10. (974) Thomsen, *8*, **148**: 368; 73. (975) Thomsen, *25*, **6**: 528; 73. (976) Thomsen, *B23*. (977) Tigerschiöeld, *220*, **107**: 67; 23. (978) Tilden, *5*, **38**: 401; 84. (979) Tilden, *135*, **52**: 111; 85.

(980) Timofejew, *7*, **6**: 141; 90. (981) Tollinger, *75*, **72**: 525, 535; 75. (982) Tolloczko, *7*, **30**: 705; 99. (983) Tolloczko, *165*, **1**: 1; 01. (984) Tolloczko and Meyer, *225*, **35**: 641; 10. (985) Trautz, *9*, **21**: 329; 15. (986) Trautz, *171*, **1914 I**: 31. (987) Trautz and Dalal, *93*, **110**: 1; 20. (988) Trautz and Geissler, *93*, **140**: 116; 24. (989) Trautz and Hinck, *93*, **93**: 177; 15.

(990) Trauts and Schlueter, *93*, **136**: 1; 24. (991) Trautz and Stäckel, *93*, **122**: 81; 22. (992) Trautz and Wackenheim, *93*, **97**: 241; 16. (993) Treadwell, *9*, **23**: 414; 16. (994) Troost, *34*, **88**: 578; 79. (994.5) Troost and Hautefeuille, *34*, **73**: 378; 71. (995) Troost and Hautefeuille, *6*, **2**: 145; 74. (996) Troost and Hautefeuille, *34*, **78**: 809; 74. (997) Troost and Hautefeuille, *6*, **9**: 56; 76. (998) Troost and Hautefeuille, *6*, **9**: 70; 76. (999) Troost and Hautefeuille, *6*, **7**: 157; 76.

(1000) Truchot, *34*, **98**: 821; 84. (1001) Truchot, *34*, **98**: 1330; 84. (1002) Truchot, *34*, **100**: 794; 85. (1003) Tucker, *62*, **215**: 319; 15. (1003.5) Tyrer, *4*, **99**: 1633; 11. **101**: 81; 12. (1004) Tzentnershver and Bruzs, *7*, **114**: 237; 24. (1005) Tzentnershver, Falk and Awerbuck, *7*, **115**: 29; 25. (1005.1) Vago, *Diss.*, Budapest, 1911. (1006) Varali-Thevenet, *59*, **4**: 186; 02. (1007) Varet, *34*, **121**: 598; 95. (1008) Varet, *6*, **8**: 79; 96. (1009) Varet, *6*, **8**: 240; 96.

(1010) Varet, *34*, **122**: 1123; 96. (1011) Varet, *34*, **123**: 118; 96. (1012) Varet, *34*, **123**: 497; 96. (1013) Verkade, Hartmann and Coops, *70*, **45**: 373; 26. (1014) Vignon, *34*, **108**: 1049; 89. (1015) Villard, *34*, **120**: 1262; 95. (1016) Villard, *6*, **11**: 289; 97. (1017) Volchowsky, *53*, **42**: 1187; 20. (1018) Vologdine, *34*, **157**: 121; 13. (1019) Vologdine and Penkiewitsch, *34*, **158**: 498; 14.

(1020) Vorobiev, *53*, **28**: 458; 96. (1021) Vrevskii and Savaritskii, *7*, **112**: 90; 24. (1022) Vriens, *7*, **7**: 194; 91. (1023) Vrzhesnevskii, *93*, **74**: 95; 12. (1024) Walden, *7*, **58**: 479; 07. (1025) Walker and Lumsden, *4*, **71**: 428; 97. (1026) Walker and Wood, *4*, **77**: 21; 00. (1027) von Wartenberg, *7*, **67**: 446; 09. (1028) von Wartenberg, *9*, **15**: 866; 09. (1029) von Wartenberg, *B13*, p. 459.

(1030) von Wartenberg, *9*, **20**: 443; 14. (1031) von Wartenberg, *13*, **440**: 97; 24. (1032) von Wartenberg and Fitzner, *93*, **151**: 313; 26. (1033) von Wartenberg and Weigel, *93*, **142**: 337; 24. (1034) Washburn and Strachan, *1*, **35**: 681; 13. (1035) Webb, *50*, **27**: 448; 23. (1036) Webb, *B18*. (1037) Wegscheider, *93*, **103**: 207; 18. (1038) Weiss and Kaiser, *93*, **65**: 345; 10. (1039) Weiss, Martin and Stimmelmayr, *93*, **65**: 279; 10.

(1040) Weiss and Neumann, *93*, **65**: 248; 10. (1041) Weiss, Piccard and Carard, *149*, **43**: 113, 199; 17. (1042) Weitzel, *93*, **116**: 71; 21. (1043) Welch and Duschak, *30*, No. **81**; 15. (1044) Werner, *6*, **27**: 570; 92. (1045) Werner, *93*, **83**: 275; 13. (1046) Winkelmann, *8*, **149**: 1; 73. (1046.5) Winkelmann, *8*, **9**: 208, 358; 80. (1047) Winkler, *7*, **9**: 171; 92. (1048) Winkler, *136*, **23**: 687; 99. (1049) Winkler, *25*, **34**: 1408; 01.

(1050) Winkler, *7*, **55**: 344; 06. (1051, 1052) Winkler, *144*, **25**: 86; 07. (1053) Winkler, *B3*, **I**: 767; 23. (1053.5) Wirtz, *8*, **40**: 438; 90. (1054) Wöhler, *9*, **11**: 836; 05. (1055) Wöhler and Balz, *9*, **27**: 406; 21. (1056) Wöhler, and Balz, *93*, **139**: 411; 24. (1057) Wöhler and Müller, *93*, **120**: 49; 21. (1058) Wöhler, Plüddemann and Wähler, *25*, **41**: 703; 08. (1059) Wöhler and Streicher, *25*, **46**: 1577; 13.

(1060) Wöhler and Streicher, *25*, **46**: 1591; 13. (1061) Wohl, *7*, **110**: 166; 24. (1062) Wohl, *9*, **30**: 36; 24. (1063) Wohl, *9*, **30**: 49; 24. (1064) Wohler and Witzmann, *9*, **14**: 97; 08. (1065) Wolff, *9*, **20**: 19; 14. (1066) Wolffenstein, *25*, **27**: 3307; 94. (1067) Woods, *3*, **2**: 268; 51. (1068) Wourtzel, *34*, **169**: 1397; 19. (1069) Wüst, Meuthen and Durrer, *150*, No. **204**: 1; 18.

(1070) Wüst and Lange, *9*, **30**: 523; 24. (1071) Yamada, *140*, **105**: 409; 22. (1072) Young, *117*, **12**: 374; 10. (1073) Zhemchuzhnui and Rambach, *93*, **65**: 403; 10. (1074) Zukowsky, *93*, **71**: 403; 11. (1075) Andrussov, *7*, **116**: 81; 25. (1076) Auerbach, *7*, **121**: 337; 26. (1077) Awbery, *67*, **39**: 417; 27. (1078) Biltz and Wein, *93*, **148**: 192; 25.

(1080) Biltz, Bröhan and Wein, *93*, **148**: 207; 25. (1081) Biltz and Mau, *93*, **148**: 170; 25. (1082) Biltz and Messerknecht, *93*, **148**: 157; 25. (1083) Bodenstein, Günther and Hoffmeister, *92*, **39**: 875; 26. (1083.5) Cohen and Helderman, *7*, **113**: 145; 24. (1084) Cohen and Joss, *64V*, **36**: 980; 27. (1085) Collenberg, *7*, **109**: 353; 24. (1086) Dewar and Jones, *5*, **85**: 574; 11. (1087) Foxton and Shutt, *83*, **23**: 480; 27. (1088) Fried, *7*, **123**: 406; 26. (1088.5) Giauque and Wiebe, *1*, **50**: 101; 28. (1089) Gjaldbaek, *93*, **144**: 269; 24.

(1090) Hantke, *92*, **39**: 1065; 26. (1091) Hare, *3*, **48**: 412; 24. (1092) Ishikawa, *41B*, **2**: 294; 27. (1093) Ishikawa and Shibata, *41B*, **1**: 169; 26. (1094) Jirsa, *93*, **158**: 33; 26. (1095) Jones and Becker, *4*, **1927**: 2669. (1096) Kameyama and Oka, *41*, **30**: 317; 27. (1097) Kast and Selle, *25*, **59**: 1958; 26. (1098) Klemm, *93*, **163**: 240; 27. (1099) Klemm and Bräutigam, *93*, **163**: 225; 27.

(1100) Matsui, Fukushima and Nakada, *41*, **30**: 330; 27. (1101) McAmis and Felsing, *1*, **47**: 2633; 25. (1102) Meyer and Scheffer, *70*, **46**: 754; 27. (1103) Prandtl and Huttner, *93*, **149**: 235; 25. (1104) Prescott and Hincke, *1*, **49**: 2744; 27. (1105) Riesenfeld and Milchsack, *93*, **85**: 401; 14. (1106) Roth, *7*, **130**: 539; 27. (1107) Schenck, Krägeloh and Eisenstecken, *93*, **164**: 313; 27. (1109) Trautz and von Dechend, *9*, **14**: 271; 08.

(1110) Vaughen and Bichowsky, *0*. (1112) Wilke and Kieninger, *7*, **116**: 215; 25. (1113) Wöhler and Martin, *245*, **12**: 1; 17.

PARTIAL AND TOTAL HEATS OF FORMATION OF AQUEOUS SOLUTIONS

F. Russell Bichowsky

ABBREVIATIONS AND SYMBOLS

x_1 Mole fraction of H_2O ("solvent").
x_2 Mole fraction of solute.
N $\frac{x_1}{x_2}$.
% Weight per cent solute.
$-H$ Total heat of formation of solute in solution, from its elements in their standard states at the same temperature (*v.* p. 169).
$-\overline{H}_2$ $\frac{\partial H}{\partial x_2}$.
$-\overline{H}_1$ $\frac{\partial H}{\partial x_1}$.

To calculate the heat of any reaction involving these solutions at constant T and p, proceed as in the case of pure substances but use partial heat of formation $\overline{H}$, instead of heat of formation H.

Example: To compute the heat of the following reaction at 60°C: $NH_3 + 4H_2O$ (in solution) $= 0.4NH_3 + 3.6H_2O$ (in solution) $+ 0.6NH_3$ (gas) $+ 0.4H_2O$ (vapor).

From the table we find:

$$76.59 + 4 \times 28542 = 0.4 \times 78.68 + 3.6 \times 284.83 + 0.6 \times 46.566 + 0.4 \times 242.35 + \overline{H}$$

Hence $\overline{H} = 36.61$ kilojoule. For further details, *v.* Lewis and Randall, Thermodynamics (1923), Chapters 4, 7, and 8.

Heat of Neutralization of Strong Acids and Bases at 20°C

The solutions contain 1 mole per 100 mole of H_2O in each case. The values tabulated are joule/equiv., on the assumption that 1g-$cal_{20} = 4.181$ joule (Richards and Rowe, *1*, **44**: 684; 22).

	$LiOH_{100}$		$NaOH_{100}$		KOH_{100}	
	Q	dQ/dt	Q	dQ/dt	Q	dQ/dt
HCl_{100}	58 254	−231.6	58 095	−220.3	58 593	−202.4
HBr_{100}	58 572		57 878		58 484	
HI_{100}	58 220		57 614		58 179	
$HNO_{3_{100}}$	57 961	−224.1	57 852	−211.1	58 894	−188.6

HCl

x_2 = HCl	x_2	0.3	0.2	0.1	0.05	0.02	0.01	0.005	0.0	$x_1 = H_2O$	
	N	2.33	4.0	9.0	19.0	49.0	99.0	199.0	∞		
gas	%	46.5	33.6	18.2	9.63	4.00	2.00	1.00	0.0	gas	liq.
92.1579	$-H$	144.4	152.3	158.84	160.95	162.50	162.84	162.80	162.46	241.89	286.848
	$-\overline{H}_2$	126.8	140.6	154.84	158.65	161.62	162.54	162.88	162.46		
0°C	$-\overline{H}_1$	294.37	289.77	287.288	286.970	286.865	286.851	286.7228	286.848		
92.1956	$-H$	144.4	152.46	159.87	162.650	164.295	164.826	165.64	165.85	241.98	286.108
	$-\overline{H}_2$	126.8	139.90	153.71	159.846	163.290	164.198	165.39	165.85		
20°C	$-\overline{H}_1$	293.62	289.242	286.760	286.250	286.1222	286.1096	286.1046	286.108		
92.2332	$-H$	144.8	153.38	161.33	165.06	166.73	167.57	168.32	169.1	242.10	285.450
	$-\overline{H}_2$	126.4	139.15	154.47	161.71	165.60	166.73	167.65	169.1		
40°C	$-\overline{H}_1$	293.4	289.02	286.183	285.617	285.4727	285.458	285.4538	285.450		
92.2667	$-H$	145.6	154.0	162.88	166.69	168.61	169.37	169.91	172.0	242.35	284.798
	$-\overline{H}_2$	126.0	138.9	156.10	163.13	167.40	168.45	169.07	172.0		
60°C	$-\overline{H}_1$	293.0	288.55	285.551	284.986	284.8236	284.805	284.802	284.798		

H_2SO_4

$x_2 = H_2SO_4$	x_2	1.00	0.80	0.60	0.50	0.40	0.20	0.10	0.05	0.002	0.00	$x_1 = H_2O$
	N	0.00	0.25	0.6667	1.00	1.50	4.00	9.00	19.0	499.00	∞	
liq.	%	100.00	95.6	89.1	84.5	78.4	57.8	37.66	22.29	1.04	0	liq.
794.581	$-H$	794.56	802.35	814.61	822.77	830.30	848.97	858.64	862.40	870.40	885.25	286.848
	$-\overline{H}_2$	794.56	794.94	796.87	802.68	812.10	832.61	847.17	860.39	867.26	885.25	
0°	$-\overline{H}_1$	320.45	318.06	313.50	306.93	298.98	290.94	288.14	286.97	286.852	286.848	
794.049	$-H$	794.06	803.27	813.73	830.68	830.01	849.30	857.17	864.12	871.99	884.08	286.103
	$-\overline{H}_2$	794.06	795.40	796.57	801.97	810.89	832.52	846.21	860.52	868.43	884.08	
20°	$-\overline{H}_1$	320.57	317.47	312.45	306.43	298.85	290.31	287.34	286.25	286.112	286.103	
793.518	$-H$	793.52	803.73	813.61	821.81	829.80	849.64	855.79	864.24	873.58	882.91	285.450
	$-\overline{H}_2$	793.52	795.90	796.28	801.22	809.71	832.44	845.16	860.65	869.60	882.91	
40°	$-\overline{H}_1$	321.12	316.97	311.49	306.01	298.85	289.77	286.63	285.63	285.459	285.450	
792.986	$-H$	792.97	804.27	812.77	821.35	829.55	845.83	854.28	864.37	875.13	881.78	284.798
	$-\overline{H}_2$	792.97	796.36	795.99	800.51	808.50	832.35	844.24	860.77	870.73	881.78	
60°	$-\overline{H}_1$	320.91	316.47	310.57	305.63	298.81	289.23	285.92	285.00	284.806	284.798	
791.919	$-H$	791.93	805.28	812.14	820.39	829.01	850.60	851.48	862.86	878.31	879.44	283.500
	$-\overline{H}_2$	791.93	797.28	795.40	799.04	806.07	832.19	842.27	861.23	873.07	879.44	
100°	$-\overline{H}_1$	321.28	315.47	308.64	304.84	298.81	288.10	284.54	283.70	283.513	283.500	
789.257	$-H_2$	789.3	807.7	809.8	818.2	827.8	852.5	845.0	861.7	886.4	873.62	280.23
	$-\overline{H}_2$	789.3	802.3	793.9	795.6	800.2	831.6	837.4	861.7	878.9	873.62	
200°	$-\overline{H}_1$	322.54	312.95	303.87	302.83	298.68	285.84	280.98	280.39	280.23	280.23	
786.596	$-H$	786.8	810.2	807.3	816.5	825.7	854.20	836.6	860.9	893.9	868.0	278.09
	$-\overline{H}_2$	786.8	801.8	792.6	791.8	793.9	831.1	832.4	862.1	884.7	868.0	
300°	$-\overline{H}_1$	330.2	311.4	300.1	301.7	300.1	283.7	278.7	277.0	278.09	278.09	

NH_3

$x_2 = NH_3$		x_2	0.5	0.4	0.3	0.2	0.1	0.05	0.02	0.01	0.00	$x_1 = H_2O$	
gas	liq.	N	1	1.5	2.333	4	9	19	49	99	∞	gas	liq.
		%	48.59	38.66	28.84	19.16	9.50	4.74	1.92	0.946	0.0		
45.4951	67.337	$-H$	76.17	78.68	79.724	80.645	81.273	81.691	81.942	81.566	81.231	241.89	286.848
		$-\overline{H}_2$	69.89	75.38	77.218	79.306	80.608	81.356	82.905	84.96	81.231		
0°C		$-\overline{H}_1$	293.0	289.02	288.30	287.17	286.961	286.857	286.827	286.815	286.848		
45.8676	66.039	$-H$	73.24	77.00	78.720	79.515	80.310	80.519	80.687	80.771	80.771	241.97	286.108
		$-\overline{H}_2$	66.12	72.82	76.17	78.092	79.682	80.310	80.645	80.771	80.771		
20°		$-\overline{H}_1$	293.4	289.18	287.18	286.4591	286.1708	286.1146	286.1067	286.1038	286.1038		
46.2191	64.909	$-H$	70.78	76.2	78.176	79.097	79.808	80.059	80.148	80.185	80.185	242.10	285.450
		$-\overline{H}_2$	62.78	71.15	75.38	77.673	79.306	79.975	80.109	80.1638	80.185		
40°		$-\overline{H}_1$	293.4	289.18	286.7	285.806	285.505	285.455	285.4518	285.4509	285.450		
46.5665	63.319	$-H$		75.38	77.548	78.469	79.138	79.306	79.348	79.389	79.431	242.35	284.798
		$-\overline{H}_2$		69.47	74.07	76.59	78.68	79.264	79.348	79.389	79.431		
60°		$-\overline{H}_1$			286.25	285.42	284.831	284.7997	284.797	284.797	284.797		
47.2109	60.892	$-H$			(76.79)	(77.42)	(77.42)	(77.42)	(77.42)	(77.84)	(77.84)	(242.90)	(284.158)
		$-\overline{H}_2$			(72.40)	(75.38)	(77.01)	(77.42)	(77.42)	(77.84)	(77.84)		
100°		$-H_1$			(288.8)	(286.8)	(284.20)	(288.35)	(284.158)	(284.158)	(284.158)		

THERMAL CONDUCTIVITY

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THERMAL CONDUCTIVITY: GASES AND VAPORS

T. H. Laby and E. A. Nelson

Thermal conductivity, k, is defined by the relation

$$\frac{dQ}{dt} = -k\, dx dy \frac{d\theta}{dz},$$

where dQ/dt is the time rate at which heat is conducted in the direction of the temperature gradient, $d\theta/dz$, across a parallel slab of area $dx \cdot dy$.

Theory.—See (1.1, 1.2, 22.1, 22.2).

Useful Formulae.—The relation, $k = f\eta c_v$ exists between the thermal conductivity, k, the viscosity, η, and the specific heat at constant volume, c_v, where f is "constant," *e.g.*, $k \propto \eta$ if the temperature varies. f depends on the number of atoms in the molecule: for diatomic gases $f = ca.$ 1.75; for triatomic *ca.* 1.4; for monatomic 2.5, which is the theoretical value for spherically symmetrical molecules (13).

Accuracy of Values of k.—The experimental determination of the thermal conductivity of gases is subject to very large error. For example, the 19 determinations of k for air deviate on the average from the weighted mean (given below) by 7 per cent. The number of observers whose observations were used in deriving the weighted means which follow is equal to the number of literature citations, excluding (8).

Units.—In all of the tables of this section the thermal conductivity, k, is expressed in kilo-erg cm^{-2} sec^{-1} $(°C, cm^{-1})^{-1}$.

Conversion Factors.—1 [kilo-erg cm^{-2} sec^{-1} $(°C, cm^{-1})^{-1}$] = 10^{-4} [joule cm^{-2} sec^{-1} $(°C, cm^{-1})^{-1}$] = 0.239×10^{-4} [cal cm^{-2} sec^{-1} $(°C, cm^{-1})^{-1}$] = 0.192×10^{-4} [BTU $ft.^{-2}$ sec^{-1} $(°F, in.^{-1})^{-1}$]. *See further* Vol. I, p. 16.

A-Table.—Elementary Substances and Atmospheric Air

Formula	t, °C	k	Lit.
A	0	1.58	(6, 7, 18, 26, 36)
Cl_2	0	0.718	(7)
H_2	0	15.9	(4, 6, 7, 8, 10, 11, 17, 22, 23, 30, 36, 38, 44); *cf.* (10.5, 24.5, 49)
He	0	13.9	(6, 7, 8, 26, 36)
Hg	203	0.772	(24)
N_2	0	2.28	(6, 7, 11, 33, 36, 38)
Ne	0	0.444	(1, 36, 37)
O_2	0	2.33	(6, 7, 11, 31, 33, 36, 38)
S	Stafford's data (29) at various temperatures appear not to be comparable with the data in this and the following tables.		
Air	0	2.23	(2, 3, 4, 8, 9, 10, 13, 17, 18, 20, 23, 26, 29, 30, 33, 36, 38, 44, 45, 46); *cf.* (10.5, 24.5, 49)

B-Table.—Chemical Compounds

Formula	t, °C	k	Lit.
H_2O	100	2.17	(19)
SO_2	0	0.768	(7)
H_2S	0	1.20	(7)
N_2O	0	1.44	(7, 31, 36, 38)
NO*	0	2.08	(7, 33, 38)

B-TABLE.—CHEMICAL COMPOUNDS.—(*Continued*)

Formula	t, °C	k	Lit.
NO_2	55	4.01	(33)
NH_3	0	2.00	(7, 22, 40, 47); *cf.* (4.5)
CO	0	2.15	(7, 16, 19, 31, 38)
CO_2	0	1.37	(4, 6, 7, 10, 17, 23, 29, 31, 33, 36, 38, 44, 47)
CCl_4	100	0.807	(19)
CS_2	0	0.636	(7)

* Observed value reduced to 0° by Sutherland's formula, using $C = 195$ from viscosity data.

C-TABLE

Formula	Name	t, °C	k	Lit.
$CHCl_3$	Chloroform	0	0.608	(19)
CH_2Cl_2	Methylene chloride	0	0.615	(19)
CH_3Br	Methyl bromide	0	0.574	(19)
CH_3Cl	Methyl chloride	0	0.841	(19)
CH_3I	Methyl iodide	0	0.433	(19)
CH_4	Methane	0	2.94	(7, 31, 36, 38, 48)
CH_4O	Methyl alcohol	0	1.32	(19)
CH_5N	Methylamine	6.5	1.51	(14)
C_2H_2	Acetylene	0	1.73	(7)
C_2H_4	Ethylene	0	1.64	(7, 16, 31, 38)
C_2H_5Br	Ethyl bromide	4.6	0.685	(19)
C_2H_5Cl	Ethyl chloride	0	0.873	(19)
C_2H_5I	Ethyl iodide	0	0.571	(19)
C_2H_6	Ethane	0	1.80	(7, 19, 48)
C_2H_6O	Ethyl alcohol	100	1.96	(19)
C_2H_7N	Dimethylamine	6.5	1.40	(14)
C_2H_7N	Ethylamine	6.5	1.34	(14, 22)
C_3H_6O	Acetone	0	0.906	(19)
$C_3H_6O_2$	Methyl acetate	0	0.938	(19)
C_3H_9N	Propylamine	6.5	1.19	(14)
C_3H_9N	Trimethylamine	6.5	1.30	(14)
$C_4H_8O_2$	Ethyl acetate	100	1.52	(19)
$C_4H_{10}O$	Ethyl ether	0	1.21	(19, 22)
$C_4H_{11}N$	Diethylamine	6.5	1.20	(14)
$C_4H_{11}N$	Isobutylamine	6.5	1.18	(14)
C_5H_{12}	*n*-Pentane	0	1.16	(19)
C_5H_{12}	Isopentane	0	1.15	(19)
$C_5H_{13}N$	*n*-Amylamine	6.5	1.11	(14)
C_6H_6	Benzene	0	0.825	(19)
C_6H_{12}	*n*-Hexylene	0	0.962	(19)
C_6H_{12}	Cyclohexane	101.8	1.64	(19)
C_6H_{14}	*n*-Hexane	0	1.03	(19)
$C_6H_{15}N$	Di-*n*-propylamine	6.5	1.02	(14)
$C_6H_{15}N$	Triethylamine	6.5	1.06	(14)

GAS MIXTURES

% = volume % of first named constituent. The values of k in italics are taken from the A-Table

$A + He$ (34) 0°C

%	k
0	*13.9*
5.39	12.29
15.32	9.700
54.63	4.503
72.96	3.100
100	*1.58*

$A + N_2$ (36) 0°C

%	k
0	2.366
21.961	2.189

$A + N_2$.—(*Cont'd*)

%	k
38.920	2.047
64.130	1.855
79.617	1.745
100	1.609

$O_2 + H_2$ (35) 22°C

%	k
0	*16.8*
5.26	15.65
14.29	13.45
25.0	11.49

$O_2 + H_2$.—(*Cont'd*)

%	k
33.33	9.922
50.0	7.639
75.0	4.649
80.0	4.14
84.64	3.84
93.94	2.99
96.64	2.72
100	*2.49*

$N_2 + H_2$ (36) 0°C

%	k
57.4	6.150

$CO_2 + H_2$ (36) 0°C

%	k	%	k	%	k
0	17.40	39.318	7.204	90.596	1.993
5.705	15.01	63.017	4.323	92.47	1.872
16.545	11.70	82.989	2.539	100	1.419

TEMPERATURE VARIATION OF THERMAL CONDUCTIVITY OF GASES

As k is not a linear function of the temperature, whenever possible a Sutherland equation,

$$k_T = k_{273}\frac{273 + C}{T + C}\left(\frac{T}{273}\right)^{3/2}$$

has been fitted to the observations, where T is the absolute temperature, and the value of the constant C so obtained is used to compute

$$\alpha_0 = \frac{1}{k_{273}}\left(\frac{dk}{dT}\right)_{273}$$

and k_T/k_{273}. When no value of C is given, no Sutherland equation would fit the observations, and the directly observed values of k_t/k_0 or of k_t are given. In parentheses is given the temperature interval over which Sutherland's equation may be applied with accuracy. If α is required for a gas not given below, it may be calculated by using a value of C obtained from viscosity observations on that gas.

A-TABLE.—ELEMENTARY SUBSTANCES AND ATMOSPHERIC AIR

A (6)

t, °C	k_t/k_0
−182.4	0.366
− 78.4	0.750
0	1.0
+100	1.31

H_2 (4, 6, 7, 23)
$C = 94$
$\alpha_0 = 0.00277$
(−252.2 to +100°)

−252.2	0.067
−200	0.304
−150	0.511
−100	0.693
− 50	0.855
0	1.0
+ 50	1.13
100	1.26

He (6, 7)
$C = 33$
$\alpha_0 = 0.00223$
(−252.2 to +100°)

−252.2	0.154*
−252.2	0.120
−200	0.399
−150	0.593
−100	0.749
− 50	0.882
0	1.0
+ 50	1.11
100	1.20

* Obs. value; but $k_t/k_0 = 0.120$ according to Sutherland's equation which fits observations above −252°.

Hg (24)
$\alpha_{182.5\text{ to }215^\circ} = 0.0074$

N_2 (6)
$C = 114$
$\alpha_0 = 0.00291$
(−191.4 to +100°)

t, °C	k_t/k_0
−191.4	0.323
−150	0.494
−100	0.680
− 50	0.848
0	1.0
+ 50	1.14
100	1.27

Ne (37)
$C = 45$
$\alpha_0 = 0.00235$
(−181.4 to +105.8°)

−181.4	0.452
−150	0.572
−100	0.736
− 50	0.876
0	1.0
+ 50	1.11
105.8	1.23

O_2 (6)
$C = 144$
$\alpha_0 = 0.00310$
(−191.4 to +100°)

−191.4	0.302
−150	0.472
−100	0.664
− 50	0.839
0	1.0
+ 50	1.15
100	1.29

Air (4, 6, 19, 23, 47)
$C = 125$
$\alpha_0 = 0.00298$
(−191.1 to 212.5°)

t, °C	k_t/k_0
−191.1	0.316
−150	0.485
−100	0.674
− 50	0.844
0	1.0
+ 50	1.14
100	1.28
150	1.40
212.5	1.55
32.5	1.09*
253.2	1.78*
430.6	2.58*
539	3.67*
t°	k_t
32.5	1.99
253.2	3.24
430.6	4.69
539	6.67

* These values of k_t/k_0 calculated from the observations of Stafford(29) when plotted against t, give a curve of opposite curvature to that obtained from the results of other observers. Caution is necessary, therefore, in combining his observations with the others given. The values given in the table are calculated relative to the value of $k_{32.5}$ obtained from Sutherland's formula, using $C = 125$.

$\mathfrak{B}$-Table.—Chemical Compounds

H_2O (19)	
$t°$	k
46	1.80
100	2.17

N_2O (7, 47)	
$t°$	k_t/k_0
− 71.8	0.771
0	1.0
+ 100	1.45

NO (7)	
−71.4	0.750*
0	1.0*

* These values satisfy Sutherland's formula, with $C = 195$, obtained from viscosity measurements.

NH_3 (7, 47)	
$t°$	k_t/k_0
− 57.6	0.744
− 36.1	0.859
0	1.0
+100	1.55

CO (7, 38)	
$C = 156$	
$\alpha_0 = 0.00316$	
(−191.0 to +7.5°)	
−191	0.296
−150	0.465
−100	0.658
− 50	0.836
0	1.0
+ 7.5	1.02

CO_2 (4, 6, 29, 47)	
$t°$	k_t/k_0
−78.4	0.667
−50	0.782
0	1.0
+50	1.24
100	1.51
36.8	1.18*
282.1	2.66*
506.7	4.62*
555	5.56*
$t°$	k_t
36.8	1.25
282.1	2.84
506.7	4.93
555	5.94

* The above values are based upon $k_{288.8}/k_0$ obtained from the results of other observers.

$\mathfrak{C}$-Table

CCl_4 (19)	
$t°$	k_t
46	0.656
100	0.807
184	1.02

CS_2 (7, 22)	
0	0.636
7.5	0.668

$CHCl_3$ (19)	
$t°$	k_t/k_0
0	1.0
46	1.21
100	1.53
184	2.04

CH_2Cl_2 (19)	
0	1.0
46	1.26
100	1.62
212.5	2.44

CH_2Br (19)	
0	1.0
100	1.70

CH_3Cl (19)	
0	1.0
46	1.36
100	1.76
184	2.45
212.5	2.79

CH_3I (19)	
0	1.0
46	1.26
100	1.64

CH_4 (7)	
−181.6	0.315
− 75.6	0.691
0	1.0

CH_3OH (19)	
$t°$	k_t/k_0
0	1.0
100	1.54

C_2H_4 (7, 47)*	
−71.1	0.636
−50	0.739
0	1.0
+50	1.29
100	1.60

* Sutherland's formula: $C = 10^6$ giving $\alpha_0 = 0.00548$.

C_2H_5Cl (19)	
0	1.0
100	1.73
184	2.45
212.5	2.76

C_2H_6 (7, 19)	
− 70.4	0.640
− 33.6	0.806
0	1.0
+100	1.78

C_2H_5OH (19, 22)	
$t°$	k
7.5	1.24
20	1.41
100	1.96

$C_2H_5NH_2$ (22)
$\alpha_{0-100} = 0.006113$

$(CH_3)_2CO$ (19)	
$t°$	k_t/k_0
0	1.0
46	1.29
100	1.72
184	2.56

$CH_3CO_2CH_3$ (19)	
$t°$	k_t/k_0
0	1.0
20	1.14

$CH_3CO_2C_2H_5$ (19)	
$t°$	k
46	1.13
100	1.52
184	2.24

$(C_2H_5)_2O$ (19)	
$t°$	k_t/k_0
0	1.0
46	1.29
100	1.70
184	2.45
212.5	2.71

n-C_5H_{12} (19)	
0	1.0
20	1.11

iso-C_5H_{12} (19)	
0	1.0
46	1.32
100	1.75
184	2.58

C_6H_6 (19)	
0	1.0
46	1.41
100	1.98
184	2.92
212.5	3.38

C_6H_{12} (19)	
Hexylene	
0	1.0
100	1.80

n-C_6H_{14} (19)	
0	1.0
20	1.10

VARIATION OF CONDUCTIVITY WITH PRESSURE

According to the dynamical theory of gases, the thermal conductivity of a gas is independent of the pressure if the mean free path is small in comparison with the thickness of the conducting layer.

According to Knudsen (15), when the free path is large in comparison with the distance between two parallel plates, the quantity of heat, Q erg, passing in time t sec, from the plate at a temperature θ_1 to that at a temperature θ_2, is

$$Q = eA(\theta_1 - \theta_2)pt$$

where A cm² is the area of each plate, p dyne cm^{-2} the pressure, and e, the "molecular coefficient of conductivity," is a function of θ and depends on the nature of the surfaces and on the nature of the gas. For a complete interchange of energy when the molecule hits the plates, e, (g^{-1} cm^{-1} sec) has the theoretical value,

$$e = \frac{1}{4}\sqrt{\frac{2}{273\pi\rho_0 T}}\,\frac{C_p + C_v}{C_p - C_v} = 1819\,(MT)^{-\frac{1}{2}}\,\frac{\gamma+1}{\gamma-1}$$

where T is the absolute temperature, ρ_0, (gram) is the mass of 1 cm³ of the gas at 273° and 1 dyne cm^{-2} pressure, and C_p, C_v, its heat capacity at constant pressure and constant volume, respectively. M = molecular weight of the gas and $\gamma = C_p/C_v$. (In calculating the dimensions of e, temperature is assumed to have the dimensions of kinetic energy.) Experiment shows that the heat transferred is smaller than this theoretical value, but approaches it as a limit for rough plates, *i.e.*, for complete exchange of energy, *v.* (25).

MOLECULAR CONDUCTIVITY OF GASES

Calculated value, conduction between absolutely rough surfaces,

$$e = 1819\,\frac{1}{\sqrt{MT}} \times \frac{\gamma+1}{\gamma-1}.$$

At 0°C, H_2, $e = 460$ g^{-1} cm^{-1} sec (*i.e.*, unit of heat = 1 erg; O_2, $e = 117$; Cl_2, $e = 127$. If unit of heat is the calorie, e for H_2 at 0° = 10.97×10^{-6}.

Observed value, Knudsen (15). H_2 at 0°C, $e = 121$ g^{-1} cm^{-1} sec for conduction between glass and rough surface; $e = 70$ for glass and glass, surfaces being cylindrical.

Schreiner's values (25), using a fine drawn platinum wire along the axis of a glass tube: mean free path must be not less than 40 times diameter of wire for data to be valid, *cf.* (27, 28).

A		O_2		H_2*		CO		N_2	
$t°$	e	$t°$	e	$t°$	e	$t°$	e	$t°$	e
0	58	0	92	0	138	0	98	0	93
− 78	69	− 78	115	− 74	168	− 78	121	− 78	120
−183	104	−204	204	−190	325	−206	221	−204	213

* If unit of heat = 1 calorie: e for H_2 at 0° = 3.31×10^{-6}.

LITERATURE

(For a key to the periodicals see end of volume. The papers giving values of the temperature coefficient are marked by an asterisk)

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THERMAL CONDUCTIVITY OF NON-METALLIC SOLIDS

M. S. Van Dusen

For industrial materials, *see* Vol. II, p. 312, 316; single crystals, p. 230; SiO_2, p. 106. Data for other non-metallic solids, and for such of the preceding as are of special importance in the construction of scientific instruments are given in the following table. Data for crystalline materials and for compressed powders are too scanty to permit any general conclusion to be drawn; the values tabulated are subject to considerable uncertainty. For conductivity of powders under reduced gas pressure, *see* Vol. II, p. 315.

Thermal Conductivity of Non-Metallic Solids

Am. = amorphous, Art. = artificial, Crys. = crystalline, Nat. = natural; B 183 = boils at 183°C; d = density of the specimen at 20°C, not of the individual grains of a powder; D = thermal diffusivity near t_R; K_t = thermal conductivity at t,°C; M 114 = melts at 114°C; p = hydrostatic pressure; P [PP] = compressed [highly compressed] powder; t_R = room temperature. $K_t = C\{1 + \alpha t(10)^{-4}\}$ if t lies within the range indicated; unless 0°C lies within the range, C is not K_0. $K_{t,p} = K_{t,1}\{1 + bp(10)^{-6}\}$. In the portion for inorganic solids, the "remarks" in section A apply also to the corresponding entries in section B.

Unit of K_t and $C = 10^{-4}$ watt/(cm°C); of $D = 1$ cm² sec^{-1}; of $d = 1$ g cm^{-3}; of $p = 1$ atm.; t_0, M, B and range are °C

Pure organic solids

Formula	Substance	t	K_t	C	α	Range	C	α	Range	Remarks	Lit.
$C_2H_2O_4$	Oxalic acid	0	90	90	−58	−190 to 0					(9)
$C_3H_8O_3$	Glycerol	0	30	30	−17	− 90 to +10	38	+ 10	−180 to −90	d = 1.263; solid*	(32)
$C_6H_6NO_3$	p-Nitrophenol	0	27	27	−19	− 50 to +50	25	− 47	−180 to −50	M 114	(32)
C_6H_7N	Aniline	−40	28.9	24	−51	−100 to −40	18	−103	−180 to −100	B 183; M −8	(32)
C_7H_9N	p-Toluidine	30	16							M 45	(30)
$C_{10}H_8$	Naphthalene	0	38	38	−33	−160 to +80				M 79	(9, 30, 32)
$C_{10}H_8O$	α-Naphthol	35	24		< 0						(30)
$C_{10}H_8O$	β-Naphthol	35	24.6	25	− 5	−170 to +100					(30, 32)
$C_{10}H_9N$	Naphthylamine	33	15		< 0					M 50	(30)
$C_{10}H_{14}O$	Thymol	12	15				D = 0.00108			M 13	(4)
$C_{12}H_{11}N$	Diphenylamine	0	22	22	− 6.5	−180 to +30				M 54	(32)
$C_{12}H_{22}O_{11}$	Sucrose	0	58	58	−45	− 80 to 0					(9)
$C_{17}H_{12}O_3$	β-Naphthyl salicylate	−80	22	20	−13	−190 to 0				Crystalline	(9)
$C_{17}H_{12}O_3$	β-Naphthyl salicylate	−80	12	14	+20	−190 to −80				Amorphous	(9)

* Probably a glass.

Pure Inorganic and Miscellaneous Solids

A. One temperature and effect of pressure

Substance		t, °C	K_t	Remarks	Lit.
AgCl	Art.	0	109	d = 3.06	(16)
AgCl	Nat.*	0	110	d = 7.2	(16)
AgCl	PP	t_R	75		(50)
AgBr		0	103	d = 5.9	(16)
Al_2O_3		15	1 050		(31)
Al_2O_3	P	t_R	68	d = 1.84	(28)
C (Dia)†	Crys.	0	15 000	D = 1.5	(10)
C (Gr)‡	Art.	0	15 000	D = 1.5	(7, 10, 18, 20, 23, 41, 45)
C	Am.	0	‡‡	D = 0.04 to 0.4	(3, 7, 18, 19, 20, 44, 49)
C (Gr)$_1$‡	P	40	119	d = 0.70; F§ 20 on 40	(45)
C (Gr)$_2$‡	P	40	38	d = 0.42; F§ 40	(45)
C (Gr)$_3$‡	P	40	18	d = 0.48; F§ 100	(45)
C (LB)‡	P	40	6.5	d = 0.165	(45)
C (CD)‡	P	40	11.2	d = 0.73	(45)
CaF_2		0	1 100		(9)
CaF_2		−190	3 900		(9)
$CaCl_2.6H_2O$		24	63		(30)
$CaSO_4.2H_2O$	Art.	t_R	38	d = 1.36; D = 0.0025	(49)
$CaSO_4.2H_2O$	Art.	t_R	74	d = 2.13	(19)
$CaSO_4.2H_2O$	Nat.‖	t_R	130	d = 2.88; D = 0.0042	(49)
$Ca_3(PO_4)_2$	PP	t_R	41		(50)
$CaCO_3$	Nat.¶	30	219	d = 2.602; b = 1.0	(6)
$CaCO_3$	Nat.¶	75	188	d = 2.602; b = 6.7	(6)
CdO	P	t_R	68	d = 3.39	(28)
Co_2O_3	P	t_R	42	d = 1.96	(28)
Cr_2O_3	P	t_R	45	d = 2.35	(28)
CuO		15	330		(31)
CuO	P	t_R	102	d = 2.19	(28)
$CuCl_2$		15	54		(31)
CuS		15	580		(31)
CuS	PP	t_R	82		(50)
$CuSO_4.5H_2O$		15	73		(31)
FeO	P	t_R	56	d = 2.24	(28)
Fe_2O_3		15	126		(31)
Fe_2O_3	P	100	49		(5)
FeS		15	710		(31)
$FeSO_4.7H_2O$		15	56		(31)
FeC_2O_4**	PP	t_R	52		(50)
H_2O (ice)	Crys.	0	209	d = 0.92; D=0.011††	(2, 13, 32, 35, 36, 42)
H_2O (snow)	Crys.		§§		(1, 22, 24, 26, 36, 38)
HgCl	PP	t_R	61		(50)
HgBr	PP	t_R	53		(50)
I		30	44		(40)
KCl		0	670		(9, 16)
KCl		−190	2 100		(9)
KI		0	500	d = 1.97	(16)

Substance		t, °C	K_t	Remarks	Lit.
$K_2Cr_2(SO_4)_4$·24H_2O		0	55		(9)
MgO		15	126		(31)
MgO	P	t_R	55	d = 0.80	(28, 50)
$MgSO_4.7H_2O$		15	48		(31)
$MgCO_3$	P	t_R	43	d = 3.0	(52)
$MgSiO_3$	PP	t_R	36		(50)
NaCl		0	670		(6, 9, 29, 31, 33, 49)
NaCl		−190	2 600		(9)
NaCl	Nat.‖‖	30	368	b = 36	(6)
NaCl	Nat.‖‖	75	316	b = 36	(6)
$NaClO_3$		0	112		(9)
$Na_2HPO_4.12H_2O$		25	54		(30)
NiO	P	t_R	94	d = 1.45	(28)
$NiSO_4.7H_2O$		15	48		(31)
$NiCO_3$	PP	t_R	58		(50)
PbO		15	210		(31)
PbO	P	t_R	72	d = 5.84	(28, 52)
Pb_3O_4		15	210		(31)
Pb_3O_4	P	t_R	55	d = 4.7	(52)
PbF_2	PP	t_R	40		(50)
$PbCl_2$		15	54		(31)
$PbCl_2$	PP	t_R	33		(50)
$PbBr_2$	PP	t_R	26		(50)
PbI_2	PP	t_R	24		(50)
PbS		15	65		(31)
S	Cryst.	−190	64		(9)
S	Crys.	0	21		(9, 19, 29, 30, 33, 36, 37)
S	Am.	0	20		(9)
Si		30	8 400		(27)
SiO_2 (glass)		0	145	*v. also* p. 106	(3, 9, 11)
TlCl		0	98	d = 6.6	(16)
TlBr		0	82	d = 7.1	(16)
ZnO		15	380		(31)
ZnO	P	t_R	59	d = 2.89	(28, 52)
$ZnSO_4.7H_2O$		15	61		(31)
Basalt (diabasic)		30	169	d = 2.924; b = 4.7	(6)
Basalt (diabasic)		75	173	d = 2.924; b = 2.2	(6)
Canada balsam		t_R	11		(12, 29)
Catlinite¶¶		30	183	d = 2.84	(6)
Chalk		t_R	71	d = 1.547; D = 0.0054	(49)
Fibre (white)		0	29	d = 1.22	(30, 46)
Ivory (⊥ axis)		80	45 to 52		(17)
Ivory (‖ axis)		80	57		(17)
Mica		t_R	40 to 60		(17, 43)
Micanite		t_R	20 to 40		(17, 43, 45)
Paraffin		0	24	D = 0.0024; M 50–54	(9, 14, 25, 29, 30, 32, 33, 34, 37, 39, 47, 48, 51)
Pyrex glass		30 to 75	109	d = 2.234, b = 4	(6)
Rubber (hard)		0	16	d = 1.2, D = 0.0016	(3, 8, 9, 16, 17, 21, 29, 30, 33, 37, 46)
Rubber (soft)		t_R	13 to 16	>90 % pure	(17, 29, 33, 47)
Shellac		t_R	25		(29, 30, 33)
Talc		30	307	d = 2.751, b = 15.7	(6)
Vaseline		t_R	18		(30, 34)

B. Variation with temperature

Substance		C	α	Range, °C	Lit.
AgCl	Art.	109	−45	0 to 100	(16)
AgBr		103	−45	0 to 100	(16)
C (Dia)†	Crys.	15 000	0	−200 to +100	(10)
C (Gr)‡	Art.	15 000	−3.3	0 to 2 000	(7, 10, 18, 20, 23, 41, 45)
C	Am.	‡‡	>0?	0 to 600	(3, 17, 18, 19, 20, 44, 49)
C (Gr)$_1$‡	P	100	+48	40 to 100	(45)
C (Gr)$_2$‡	P	33	+40	40 to 100	(45)
C (Gr)$_3$‡	P	16	+34	40 to 100	(45)
C (LB)‡	P	6.4	+6	40 to 150	(45)
C (CD)‡	P	10.3	+23	30 to 150	(45)
CaF_2		1 100	−37	−80 to +100	(9)
Fe_2O_3	P	39	+25	100 to 700	(8)
H_2O (ice)	Crys.	209	−17	−170 to 0	(2, 13, 32, 35, 36, 42)
H_2O (snow)	Crys.	§§			(1, 22, 24, 26, 36, 38)
KCl		670	−44	−180 to +100	(9, 16)
NaCl		670	−44	−80 to +100	(6, 9, 29, 31, 33, 49)
$NaClO_3$		112	−52	−80 to 0	(9)
S	Crys.	21	−25	0 to 100	(9, 19, 29, 30, 33, 36, 37)
S	Am.	20	+10	−190 to 0	(9)
SiO_2 (glass)		145	+23	−250 to +100	(3, 9, 11)
TlCl		98	−43	0 to +100	(16)
Fibre (white)		29	+12	0 to 80	(30, 46)
Paraffin		24	−16	−180 to +30	(9, 14, 25, 29, 30, 32, 33, 34, 37, 39, 47, 48, 51)
Rubber (hard)		16	+6	−200 to +100	(3, 8, 9, 16, 17, 21, 29, 30, 33, 37, 46)

* Horn silver, cerargyrite.

† Diamond. If $t < -200$°C, K decreases with t.

‡ (Gr) = graphite, (LB) = lampblack, (CD) = coal dust.

§ F 20 on 40 means that the powder passed a sieve of 20 meshes to the inch, but was caught by one of 40; F 40 means that it passed a sieve of 40 meshes but that no indication of the limit of fineness of the powder is given.

‖ Gypsum.

¶ Limestone, nearly pure $CaCO_3$.

** Ferrous oxalate.

†† In the range 0 to −30°C.

‡‡ Values of K_0 and C vary from 400 × 10^{-4} to 4000 × 10^{-4} watt/(cm, °C).

§§ In the range 0 to −30°C, $K = (2.1 + 42d + 216d^2) \times 10^{-4}$ watt/(cm °C), $D = (d^{-1} + 20 + 103d^2) \times 10^{-4}$ cm^2 sec.$^{-1}$

‖‖ Rock salt, clear crystalline.

¶¶ Catlinite = pipestone.

p	1	2 000	4 000	6 000	8 000	10 000	12 000 atm.
K_{20}	183	212	228	235	240	245	249 × 10^{-4} watt/(cm, °C)

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(For a key to the periodicals see end of volume)

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THERMAL CONDUCTIVITY OF LIQUIDS AND SOLIDS

T. Barratt and H. R. Nettleton

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STANDARD MATERIALS

The materials in the following table are suitable for standardizing, calibrating, or checking of scientific apparatus and instruments.

$K_t = K_0(1 + \alpha_0 t)$, $0° \leq t \leq 100°C$; $K_t = K_{20}[1 + \alpha_{20}(t - 20)]$, $0° \leq t \leq 80°C$; t = centigrade temperature.

Unit of $K = 1$ watt/(cm °C) = 0.2389 cal_{15}/(cm sec °C) = 1.338×10^{-3} BTU_{60}/(in. sec °F)

	K_0	α_0		K_{20}	α_{20}
Ag.....	4.19	−0.00017	H_2O.....	0.00587	+0.00281
Cd.....	0.933	−0.00038	C_2H_5OH...	0.00182	−0.00071
Pb	0.352	−0.00016	SiO_2;*v.*p.106		

METALS AND ALLOYS

About 75% of all measurements of the thermal conductivity of pure metals and of alloys were for the purpose of testing either Wiedemann and Franz's law (**115**), that the ratio of the thermal (K) to the electrical (σ) conductivity is the same for all metals, or Lorenz's law (**70**), that K/σ is proportional to the absolute temperature T. The most important papers on these subjects are (**3, 6, 11, 12, 15, 19, 23, 24, 30, 33, 36, 41, 49, 50, 51, 52, 53, 54, 57, 63, 64, 65, 66, 67, 70, 73, 74, 75, 77, 79, 83, 84, 92, 94, 95, 97, 98, 102, 114, 115, 120**).

On the electron theories of Riecke (**92.5**), Drude (**22.5**) and others, $K/\sigma T = \frac{4}{3}(e_0/e)^2 = 3(k_0/e)^2$, a quantity which is independent of the metal and of T; k_0 = Boltzmann's molecular gas constant, e = electronic charge. With the values accepted for I. C. T., this gives $10^8 K/\sigma T = 2.23$ watt-ohm-(°C)$^{-2}$. For observed values, *see* Table 1.

For the effects of mechanical stresses, *see* Table 2.

Table 1.—Relation of Thermal (K) to Electrical (σ) Conductivity

Tabular values are $A = 10^8 K/\sigma T$; theoretical value of $A = 2.23$ watt-ohm/(°C)^2, on basis of the "accepted constants" (Vol. I, p. 17).

Unit of $A = 1$ watt-ohm/(°C)^2 = 10^{16} cgsm.

	A_{-170}	A_{-100}	A_0	A_{18}	A_{100}
Al.....	1.50	1.81	2.09	2.19	2.27
Ag.....	2.04	2.29	2.33	2.36	2.37
Au.....			2.45§		2.41§
C‖.....			1110§		770§
Cd.....	2.39	2.43	2.40	2.43	2.44
Cu.....	1.85	2.17	2.30	2.29	2.32
Fe.....	3.10	2.98	2.97	2.76	2.85
Ir.....			1.77§		1.60§
Mo.....			3.08§		3.17§
Ni.....	2.92	2.59	2.59	2.40	2.44

Cr-Fe,* chrome steels

% Cr	A_{30}†	A_{30}‡
0	2.86	2.79
0.5	3.01	2.73
1	2.91	2.79
2	2.79	2.75
3	3.14	2.80
5	3.24	2.75
8.5		2.72
10	3.26	

TABLE 1.—(*Continued*)

	A_{-170}	A_{-100}	A_0	A_{18}	A_{100}	Cr-Fe,* chrome steels		
						% Cr	A_{30}†	A_{30}‡
Pb	2.55	2.54	2.53	2.46	2.51	13		2.73
Pd			2.18§		2.16§	15	2.86	
Pt			2.47§		2.59§	17		2.74
Rh			1.55§		1.33§	20	3.03	
Sn	2.48	2.51	2.49	2.53	2.49			
Ta			2.88§		2.78§			
Zn	2.20	2.39	2.45	2.31	2.33			
Mean	2.34	2.41	2.41	2.41	2.38			
	(67)				(57)			

* *See* Fig. 1 (75).
† Annealed 900°C.
‡ Quenched 1100°C.
§ (6).
‖ Graphite (omitted from mean).

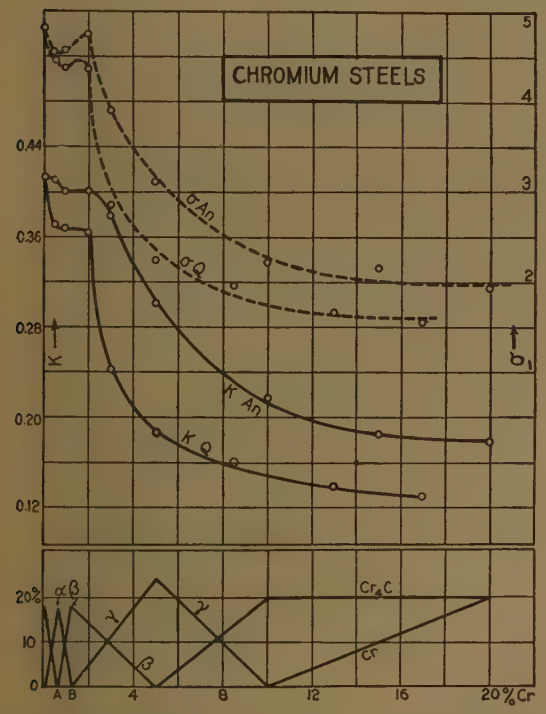

FIG. 1.—Thermal (K) and electrical (σ) conductivities of chrome steels: Variation with composition and heat treatment (75).

Unit of K = 1 watt/cm °C, of $\sigma = 10^4$ ohm^{-1} cm^{-1}. An = annealed from 900°C; Q = quenched at 1100°C. Similar curves are obtained for the coefficient of expansion and for the moduli of elasticity; their shape is intimately related to the variations in the amounts of the several phases present. (*See* lower section of figure; A = 0.6 %, B = 1.2 % of Cr; α, β, γ refer to the α, β, γ double carbides.)

Fe-W, tungsten steels; t = 30°C (52); (*see* Fig. 2)

W, % \ C, %	0.3	0.6	W, % \ C, %	0.3	0.6	W, % \ C, %	0.3	0.6
0	2.47	2.68	3		2.50	15	2.71	2.51
0.5	2.51	2.62	5	2.68		20	2.63	2.53
1	2.58	2.52	6	2.66	2.53	25	2.67	2.48
2	2.68	2.49	10		2.51			

Fe-C, steel, iron, nickel (53) ‖ Manganin

Material	30°	200°	400°	600°	800°	‖ t	A_t
Carbon Steel						‖ −170	5.94
C* = 0.18 %	2.59	2.63	2.76	2.68	3.02	−100	4.16
C* = 0.64 %	2.56	2.70	2.94	2.95	3.15	0	3.41
C* = 1.02 %	2.77	2.76	3.11	3.27	3.25	18	3.14
C* = 1.50 %	2.58	2.48	2.78	2.93	3.14	100	2.97
Swedish iron	2.85	3.03	3.08	3.00	3.28	(57, 67)	
Ni	2.17	2.53	2.67	2.73	2.75		

* Krupp carbon steel, same specimen as in Table 4 "Tool or high carbon steel" No. 2.

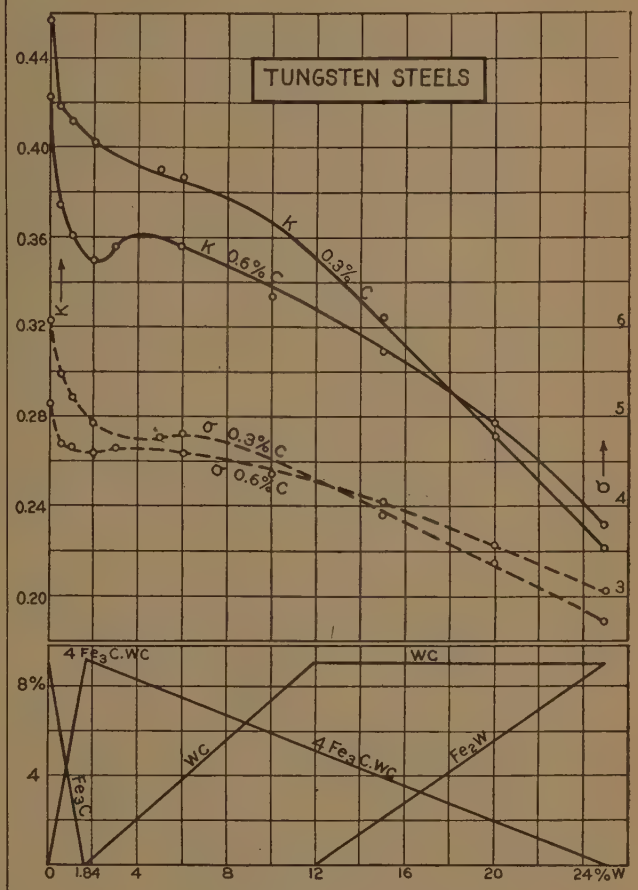

FIG. 2.—Thermal (K) and electrical (σ) conductivities of tungsten steels: Variation with composition (52).

Unit of K = 1 watt/cm °C, of $\sigma = 10^4$ ohm^{-1} cm^{-1}. Similar curves are obtained for the moduli of elasticity; their shape is intimately connected with the variations in the amounts of the several phases present. (*See* lower section of figure.)

TABLE 2.—THERMAL CONDUCTIVITY (K) OF METALS: EFFECT OF STRESSES

K varies nearly linearly with hydrostatic pressure (P) and with tensile stress (S); under torsion, K varies approximately as the square of the twist (τ).

K_0 = conductivity of unstressed material at 0°C; K, K_P, K_S, K_τ = conductivity at the same temperature unstressed, under stress P, S, τ.

K'_S = apparent conductivity under stress S, assuming dimensions are the same as for unstressed specimen. S_m, τ_m = maximum values used in measurements.

TABLE 2.—(*Continued*)

$\delta_P \equiv 10^6(K_P - K)/KP$; $\delta_S \equiv 10^6(K_S - K)/KS$; $\delta_S' \equiv 10^6(K_S' - K)/KS$; $A_\tau \equiv 100(K_\tau - K)/K\tau^2$

Unit of P and S = 1 kg/cm² = 9.81 × 10⁵ dyne/cm² = 0.97 A_n; of τ = 1°/cm = 0.0174 radian/cm = 30.5°/ft.

Material	K_0	δ_P*	S_m	δ_S†	S_m‡	δ_S'	τ	A_τ§
Ag	4.19	− 3.7	790	−2.0				
Al	2.03		545	−3.8	463	13.8	1.84	−0.27
Bi	0.0837	−31						
Cd	0.933	+ 7.4						
Cu	3.88	− 7.5	1080	−2.1	463	8.0	0.74	−0.64
Cu-Zn‖	1.05				463	6.3	1.32	−0.57
Fe	0.619	− 0.3	2050	−1.9			1.13	−0.59
Steel	0.485				1235	6.2	0.88	−2.78
Ni	0.586	−12	1900	+0.48	964	4.2	0.81	−0.61
Pb	0.352	+17.3					1.10	−0.21
Pd	0.674		770	−0.20				
Pt	0.695	− 1.6	790	−1.35				
Sb	0.186	−21						
Sn	0.657	+12					0.74	−1.83
Zn	1.13	+ 2.1			463	8.2	0.59	−2.01
Lit.	(14); *cf.* (71)		(15); *cf.* (103)		(59)		(18, 68); *cf.* (104)	

* Metals very pure, maximum hydrostatic pressure = 12 000 kg/cm².
† Metals very pure; allowance made for change in dimensions due to stretching. Probable errors range from 2.4 % for Al to 23 % for Ni.
‡ Approximately 70 % of elastic limit.
§ Metals not annealed.
‖ Brass.

TABLE 3.—THERMAL CONDUCTIVITY (K_0) AT 0°C OF PURE METALS

K_0 = weighted mean of best determinations; "Range" = limiting values between which the true value probably lies.

Unit of K = 1 watt/(cm °C) = 0.2389 cal_{15}/(cm sec °C) = 1.338 × 10⁻³ BTU_{60}/(in. sec °F) = 10⁷ erg/(cm sec °C).

Symbol	K_0	Range	Lit.
Ag	4.19	4.05 –4.30	(35, 46, 57, 67, 99, 110); *cf.* (34)
Al	2.03	1.95 –2.15	(4, 57, 58, 67, 73, 96, 117)
Au	2.96	2.85 –3.10	(6, 57, 77); *cf.* (35, 99, 100)
Bi	0.0837	0.080 –0.091	(30, 33, 57, 60, 70)
C*	0.0345	0.0325–0.0365	(7); *cf.* (28, 116)
C†	0.157	0.150 –0.165	(7, 55); *cf.* (108)
Cd	0.933	0.91 –0.95	(24, 57, 67, 70, 96, 110)
Co‡	K_{20} = 0.692		(51)
Cu	3.88	3.85 –3.95	(36, 57, 62, 67, 77, 89, 93, 96)
Fe	0.619	0.57 –0.67	(8, 12, 40, 53, 57, 67, 70, 102); *cf.* (9, 27, 34, 79, 97, 109)
Fe§	0.485	0.44 –0.51	(17, 36, 53, 57, 67); *cf.* (34, 64)
Hg	0.0836	0.0820–0.0845	(11, 12, 81, 112); *cf.* (2, 32, 48, 69, 80, 111)
Ir	0.59	0.56 –0.62	(6)
K	0.99		(54)
Li	0.70	0.63 –0.77	(78)
Mg	1.55	1.50 –1.65	(70, 73)
Mo	1.46	1.38 –1.54	(6)
Na	1.35	1.25 –1.45	(54); *cf.* (19, 90)
Ni	0.586	0.565 –0.605	(5, 53, 57, 67); *cf.* (8)
Pb	0.352	0.34 –0.36	(12, 34, 57, 62, 63, 67, 70, 72, 77, 85, 88, 96)
Pd	0.674	0.61 –0.69	(6, 57, 99)
Pt	0.695	0.685 –0.700	(6, 57, 77, 97)
Rh	0.894	0.87 –0.91	(6)
Sb	0.186	0.16 –0.21	(12, 24, 30, 70)
Se	(*See* Table 4)		
Sn	0.657	0.625 –0.675	(3, 12, 34, 57, 61, 67, 70, 85); *cf.* (4, 63)

TABLE 3.—(*Continued*)

Symbol	K_0	Range	Lit.
Ta	0.544	0.52 –0.57	(6)
Te	K_{45} = 0.06		(118)
Tl	0.39		(16)
W	1.60		(113); *cf.* (6)
Zn	1.13	1.06 –1.19	(12, 57, 63, 67); *cf.* (34)

* Gas carbon.
† Graphite.
‡ With 0.24 % C, 1.4 % Fe, 1.1 % Ni, 0.14 % Si.
§ Steel with *ca.* 1 % C.

TABLE 4.—THERMAL CONDUCTIVITY (K) OF METALS, Cu_2S, Fe_2O_3, AND ZnO: VARIATION WITH TEMPERATURE

For alloys of definite composition, *see* Table 5.

In certain cases the recorded values of K have been adjusted so as to give in each case a K_0 which agrees with the weighted mean given in Table 3. These cases are indicated by an *a* in the column "Notes."

s = solid; l = liquid; t', t'' = limits of temperature range within which the formula of variation applies; α, β = coefficients defined by the equation

$$K_t = K_{t'}[1 + 10^{-3}\alpha(t - t') + 10^{-6}\beta(t - t')^2]$$

if "(K_0)" or K_0' is written in the $K_{t'}$ column, the equation is

$$K_t = K_0[1 + 10^{-3}\alpha t + 10^{-6}\beta t^2]$$

or

$$K_t = K_0'[1 + 10^{-3}\alpha t + 10^{-6}\beta t^2]$$

depending upon whether 0°C does or does not lie within the range defined by t' and t''. In the latter case the value of K_0' is always given.

Example: For Ag, $K_t = 4.19(1 - 0.00017t)$, if $0° \leq t \leq 100°$; $K_t = K_0(1 - 0.00054t - 0.00000266t^2)$, if $18° \geq t \geq -170°$. If $K_0 = 4.19$ and $t = -100$°C, $K_{-100} = 4.19[1 - 0.00054(-100) - 0.00000266(-100)^2] = 4.19(1 + 0.054 - 0.0266) = 4.19(1.0274) = 4.30$. For Al, the data from (67) give $K_t = K_0(1 + 0.000175t)$, if $18° \geq t \geq -125°$ and $K_t = 1.98[1 - (10)^{-3}1.49(t + 125)]$, if $-125° \geq t \geq -170°$.

Unit of K = 1 watt/(cm °C) = 0.2389 cal_{15}/(cm sec °C); of α = (1°C)⁻¹; of β = (1°C)⁻²; t = centigrade temperature.

Symbol	Notes	t'	t''	$K_{t'}$	α	β	Lit.
Ag	*a*	0	100	4.19	−0.17		(57)
	a	18	−170	(K_0)	−0.54	−2.66	(67)
Al	*a*	0	100	2.03	+0.29		(57)
	a	0	100	2.03	+0.184		(70)
		18	−125	(K_0)	+0.175		(67)
	a	−125	−170	1.98	−1.49		(67)
	s, *a*	0	650	2.03	−0.275	−0.34	(65)
	l, *a*	650	800	0.90	−0.32		(65)
		100	400	2.19	+0.137		(95)
	$K_{-252.4}$* = 1.55; $K_{-251.4}$ = 1.63; $K_{-188.3}$ = 1.90; K_0 = 1.93						(96)
Au	*a*	0	100	2.96	+0.04		(57)
		0	100	(K_0)	−0.07		(6)
	a	$K_{-251.6}$ = 12.4; $K_{-181.6}$ = 3.08; K_0 = $K_{21.6}$ = $K_{100.6}$ = 2.96					(77)
Bi†	*a*	0	100	0.0837	−1.97		(57)
		0	100	(K_0)	−0.17		(70)
	±8 % *a*	K_{-190} = 0.220; K_{-78} = 0.0945; K_{100} = 0.080					(30, 33); *cf.* (72)
	s, *a*	K_{100} = 0.0770; K_{200} = 0.0756; K_{250} = 0.0775					(65)
	l, *a*	K_{300} = 0.176; K_{400} = 0.159; K_{500} = 0.157; K_{600} = 0.156					(65)
		A† = 25: K_{-183} = 0.266; K_0 = 0.113					(25)
		A† = 0.017: K_{-183} = 0.098; K_0 = 0.068					(25)
		K‡$_{-150}$ = 0.209; K_0 = 0.0812; K_{100} = 0.0507					(30)
C§	(Except graphite)						
	(1) *a*	0	100	0.0345	+1.5		(7)
	(2)	30	150	0.00111	+2.3		(106)
	(3)	1427	1827	0.084	+0.12		(119)
	(4)	30	3500	mean K = 0.068			(45)
	(5)	K_{100} = 0.059; K_{200} = 0.063; K_{300} = 0.059; K_{400} = 0.046; K_{500} = 0.050; K_{2000} = 0.0071					(45)
	(6)	K_{220} = 0.372; K_{425} = 0.520; K_{520} = 0.540; K_{750} = 0.574; K_{1050} = 0.602					(47)

TABLE 4.—(*Continued*)

Symbol	Notes	t'	t''	$K_{t'}$	α	β	Lit.
C‖	(Graphite)						
	(1) *a*	0	100	0.157	+0.33		(7)
	(2)	0	555	(K_0)	−2.36	+24.2	(55)
	(3)	50	100	0.441	+1.2		(106)
	(4)	$K_{100} = 1.92$; $K_{200} = 1.50$; $K_{300} = 1.32$; $K_{400} = 1.18$; $K_{500} = 1.11$; $K_{600} = 1.03$; $K_{3000} = 0.0071$					(45)
	(5)	$K_{245} = 1.41$; $K_{323} = 1.36$; $K_{410} = 1.28$; $K_{507} = 1.22$; $K_{750} = 1.17$; $K_{1050} = 1.05$					(47)
	(6)	30	2830	mean $K = 0.68$			(47)
	(7)	40	100	0.0119	+4.8		(106)
	(8)	40	100	0.0386	+4.0		(106)
	(9)	40	100	0.00183	+3.4		(106)
Cd	*a*	0	100	0.933	−0.38		(57)
		−170	+18	(K_0)	−0.564		(67)
	s, *a*	0	320	0.933	+1.2		(16)
	l, *a*	320	440	0.451	+2.8		(16)
		$K_{-252.7} = 2.35$; $K_{-251.9} = 2.00$; $K_{-251.5} = 1.81$; $K_{-250.7} = 1.67$; $K_{-185.1} = 1.03$					(96)
Cu¶	*a*	0	100	3.88	−0.12		(57)
	a	0	100	3.88	−0.26		(57)
	a	−125	−170	4.18	−2.4		(67)
		18	−125	(K_0)	−0.31	+2.5	(67)
		76	362	(K_0)	−0.09		(62)
		100	600	3.78	−0.13		(95)
	a	$K_{-252.4} = 17.45$; $K_{-251.1} = 13.0$; $K_{-184.5} = 4.72$; $K_{-77.1} = 3.97$					(77, 96)
	(1)	$K_{-252.7} = 127.1$; $K_{-252.5} = 124.6$; $K_{-252.0} = 120.5$; $K_{-200} = 8.16$; $K_{-190.1} = 5.94$					(96)
	(2)	$K_{+148} = 4.37$; $K_{184} = 4.05$; $K_{235} = 3.90$; $K_{320} = 3.78$; $K_{368} = 3.59$; $K_{750} = 3.43$; $K_{1050} = 3.26$					(47)
	(3)	An, $K_{150} = 3.77$; *D*, $K_{150} = 3.68$; *C*, $K_{150} = 3.22$					(117)
	(4)	157		3.18			(117)
	(5)	An, $K_{175} = 2.09$; *D*, $K_{165} = 2.18$					(117)
	(6)	0.63 % P, $K_{30} = 1.05$; 1.98 % P, $K_{30} = 0.523$					(89); *cf.* (36)
Cu_2S		16	555	0.00444	+4.06		(55)
Fe	Wrought iron, C ≤ 0.1 %; *v. also* (27, 29)						
		0	100	(K_0)	−0.14		(57)
		0	100	(K_0)	−0.65		(57)
		0	100	(K_0)	−0.23		(70)
		28	58	(K_0)	−0.3		(40)
	*a***	−50	−170	0.623	−1.16	−8.26	(67)
	*a***	18	−50	(K_0)	−0.136		(67)
	††	$K_{30} = 0.561$; $K_{100} = 0.545$; $K_{200} = 0.515$; $K_{300} = 0.486$; $K_{400} = 0.444$; $K_{500} = 0.402$; $K_{600} = 0.364$; $K_{700} = 0.352$; $K_{800} = 0.322$; $K_{850} = 0.326$					(53)
	Cast iron,‡‡ C ≥ 3 %; *v. also* (9, 43)						
	1	$K_{200} = 0.32$; $K_{300} = 0.43$; $K_{400} = 0.60$; $K_{450} = 0.67$; $K_{500} = 0.80$; $K_{550} = 0.86$					(42)
	2	$K_{114} = 0.448$					(38)
	3	$K_{113} = 0.436$					(38)
	4	20	75	$(K)'_0$	−1.0	($K'_0 = 0.643$)	(43)
	5	$K_{54} = 0.479$; $K_{102} = 0.466$					(17)
	Mild steel,§§ C = 0.1 % *ca.*:						
	1	0	−170	0.485	+0.15		(67)
	2	$K_{27} = 0.555$; $K_{59} = 0.544$					(39)
	3	$K_{200} = 0.916$; $K_{414} = 0.846$; $K_{506} = 0.771$; $K_{672} = 0.800$; $K_{750} = 0.754$; $K_{1050} = 0.745$					(47); *cf.* (63)
	Tool or high carbon steels,‖‖ C = 1 % *ca.*:						
	1	0	100	(K_0)	−0.09		(57); *cf.* (34)
	2	30	$K_f = 0.559 - 0.135b - 0.0812c$				(102)
			$K_a = 0.509 - 0.0833b - 0.0774c$				(102)
			$K = 0.537 - 0.130b - 0.129c$				(102)
	3	40	*L*, 0.425	0.60	Unv.		(106); *cf.* (37, 87)
		40	*T*, 0.0062	2.5	Unv.		(106); *cf.* (37, 87)
		20	*T*, 0.0197	1.0	Asp.		(106); *cf.* (37, 87)
		20	*T*, 0.0057	1.9	Var.		(106); *cf.* (37, 87)
	4 (*a*)	85	*T*, 0.0164	1.0			(106)
	(*b*)	85	*T*, 0.0125	5.3			(106)
	(*c*)	85	*T*, 0.0094	1.2			(106)
	(*d*)	85	*T*, 0.0106	6.0			(106)

TABLE 4.—(*Continued*)

Symbol	Notes	t'	t''	$K_{t'}$	α	β	Lit.
Fe_2O_3¶¶		150	720	0.00523	+1.93		(13)
		720	1050	0.0109	+1.53		(13)
Hg	*a*	0	100	0.0836	0		(11, 12, 82); *cf.* (32)
	s	−44	−193	0.28	−5		(32)
	s	$K_{-269.3} = 1.67$; $K_{-268.3} = 1.13$					(86)
Ir	*a*	0	100	0.59	−0.51		(6)
K	*a*	0	60	0.99	−1.34		(54)
Mg	*a*	0	100	1.55	0		(70)
		$K_{100} = 1.39$; $K_{200} = 1.35$; $K_{300} = 1.30$; $K_{400} = 1.30$; $K_{500} = 1.33$					(95)
Mo	*a*	0	100	1.46	−0.45		(6)
Na	*a*	0	90	1.35	−1.23		(54)
Ni	*a*	0	100	0.586	−0.31		(57); *cf.* (1, 38)
		+18	−170	(K_0)	+0.504		(67)
	a	$K_0 = K_{100} = 0.586$; $K_{200} = 0.578$; $K_{300} = 0.555$; $K_{400} = 0.524$; $K_{500} = 0.550$: $K_{600} = 0.572$; $K_{700} = 0.590$; $K_{800} = 0.617$; $K_{850} = 0.625$					(53)
		$K_{100} = 0.608$; $K_{200} = 0.575$; $K_{300} = K_{400} = K_{500} = 0.537$; $K_{600} = 0.565$; $K_{700} = 0.590$					(95)
Pb	*a*	0	100	0.352	−0.16		(57)
		90	210	(K_0)	−0.17		(62)
	s, *a*	0	325	0.352	−0.40		(65); *cf.* (85)
	l, *a*	325	600	0.165	−0.20		(65); *cf.* (85)
	a	0	− 75	0.352	−0.24		(67)
	a	−75	−170	0.357	−0.99		(67)
		$K_{-252.5} = 0.577$; $K_{-250} = 0.508$; $K_{-184} = 0.414$					(72, 77, 96)
Pd	*a*	0	100	0.674	+0.68		(57)
		0	100	(K_0)	−0.08		(6)
Pt	*a*	0	100	0.695	+0.53		(57)
		0	100	(K_0)	+1.8		(6)
	a	$K_{-252.4} = 3.62$; $K_{-181.7} = 0.758$; $K_0 = 0.695$; $K_{21.1} = 0.697$; $K_{100.7} = 0.702$					(77)
Rh	*a*	0	100	0.894	−1.0		(6)
Sb	*a*	0	100	0.186	−1.4		(70)
		$K_{-183} = 0.2025$; $K_0 = 0.1716$ (A*** = 0.0141)					(25)
		$K_{-183} = 0.4519$; $K_0 = 0.2452$ (A*** = 14.3)					(25)
	a	$K_{-190} = 0.367$; $K_{-80} = 0.217$; $K_0 = 0.186$; $K_{100} = 0.179$					(31); *cf.* (24)
Se		*K* changed by illumination, but effect is very small. (*See* p. 230.)					
Sn	*a*	0	100	0.657	−0.8		(57)
	a	+18	−100	(K_0)	−1.0		(67)
	a	−100	−170	0.723	−1.54		(67)
	s, *a*	0	232	0.657	−0.41		(16)
	l, *a*	232	500	0.369	−0.66		(16)
	s, *a*	0	232	0.657	−0.47		(65)
	l, *a*	232	500	0.342	−0.20		(65)
Ta	*a*	0	100	0.544	−0.10		(6)
		1427	1827	0.73	+0.34		(119)
Tl	*s*	$K_{50} = 0.392$; $K_{100} = 0.405$; $K_{150} = 0.389$; $K_{200} = 0.445$					(16)
	l	350		0.247			(16)
W†††	1	0	100	(K_0)	−0.10		(6)
	2	$K_{1227} = 1.01$; $K_{1427} = 1.07$; $K_{1627} = 1.12$; $K_{1827} = 1.17$; $K_{2027} = 1.21$; $K_{2227} = 1.25$;					(120); *cf.* (66)
	3	$K_{2427} = 1.29$					
		$K_{727} = (0.84)$; $K_{1227} = 0.99$; $K_{1727} = 1.11$; $K_{2227} = 1.21$; $K_{2527} = (1.27)$					(29)
Zn	*a*	0	100	1.13	−0.15		(57)
	a	+18	−125	(K_0)	−0.081		(67)
		−125	−170	1.13	−0.74		(67)
	s, *a*	0	420	1.13	−0.10	−0.83	(65)
	l, *a*	420	600	0.587	−0.13		(65)
		$K_{100} = 1.07$; $K_{200} = 1.02$; $K_{300} = 0.99$					(95)
ZnO		?		0.00695			(116)

* Commercial aluminium.

† *See also* p. 231, Table 15. A = mean area of crystals; unit = 1 mm².

‡ Bi powder, compressed 5000 kg/cm².

§ (1) = Gas carbon, $d = 1.42$ g/cm³. (2) = Lampblack. (3) = Untreated lamp filaments. (4) = Carbon "Idler." (5) = Petroleum coke. (6) = Carbon electrodes for furnaces, K measured under operating conditions.

‖ (1) = Graphite, $d = 2.11$. (3) = Solid graphite, $d = 1.58$. (4) = Acheson graphite. (5) = Graphite electrodes, K measured under operating condi-

tions. (6) = Graphite "Idler." (7), (8), (9) = Powdered graphite, compressed 3 kg/cm²; d = 0.70, 0.42, and 0.48, respectively; the powder passed sieves of 8, 16, and 40 meshes per cm, respectively.

¶ (1) = Natural crystal. (2) = Cu electrode, K measured under operating conditions. (3) = Electrolytic Cu; An = annealed, Cu = 99.98 %; D = hard-drawn, Cu = 99.97 %; C = cast, Cu = 99.98 %. (4) = Lake Cu, cast, Cu = 99.76 %. (5) Contains Cu, 99.44 %; Ni, 0.20 %; Fe, 0.036 %; As, 0.231 %; An = annealed: D = hard-drawn. (6) Cu containing P, as indicated. Additional references for Cu: (4, 8, 11, 20, 34, 35, 61, 63, 76, 91).

** Contains 99.4 % Fe, 0.14 % Mn, 0.13 % Ni, 0.1 % C.

†† Swedish charcoal iron.

‡‡ (1) 3.5 % C, 0.64 % Mn, 2.2 % Si; Soft gray. (2) Very brittle, d = 7.06; Southern. (3) 3.64 % C, 1.33 % Si, 0.59 % P; Gun-iron. (4) 3.5 % C, 0.52 % Mn, 1.40 % Si, 0.55 % P, 0.052 % Cu, 0.106 % S. (5) 3 % C, 1 % Mn, 3 % Si, 1 % P.

§§ 2. Open hearth, boiler plate; 0.1 % C, 0.35 % P. 3. Cold-rolled mild steel; electrodes.

‖‖ 2. Krupp carbon steels; 12 kinds: C, 0.14 % to 1.5 %; Si, 0.05 % to 0.34 %; Mn, 0.27 % to 0.67 %; P, 0.01 % to 0.051 %; S, 0.014 % to 0.044 %; Cu, 0.05 % to 0.13 %. f = forged; a = annealed *in vacuo*, 900°C, 1 hr; q = quenched in oil from 900°C. In the equations in the table, b = sum of atomic percentages of Mn and Si; c = % C.

t =	30	100	200	300	400	500	600	700	800	850
C, %	1000 K_t (53)									
0.18	452	452	452	427	402	372	360	364	305	309
0.44	339	339	339	335	326	305	297	259	305	309
0.64	439	439	435	410	410	337	355	339	251	259
0.80	423	435	423	423	402	389	352	393	297	293
1.02	431	423	431	414	414	402	381	414	309	318
1.30	360	360	368	368	360	339	318	414	326	322
1.50	360	360	364	355	347	326	309	372	272	272

For relation of K to electrical conductivity, *see* Table 1, Fe-C.

3. Steel stampings, stacked. L = along the laminations, T = across them; by inserting suitable material between the sheets, K can be increased some 3 or 4 times. "W. A." silicon steel gave results similar to those tabulated. Unv. = unvarnished: Asp. = coated with asphalt paint; Var. = varnished.

4. Sheet steel, sheets stacked and under pressure of 8.7 kg/cm²; about 3 % of total volume = air space and 9.5 % = varnish. (a) = ordinary sheet steel; (b) = same, enamelled; (c) = silicon sheet steel, oxide coated; (d) = same, enamelled. T denotes that K is measured across the laminations.

¶¶ Compressed powder.

*** A = Mean area of crystals; unit = 1 mm².

††† 1. "Pladuram." 3. Aged W filaments, values in parentheses are extrapolated.

Table 5.—Thermal Conductivity (K) of Alloys and Amalgams

For certain commercial metals (Fe, Cu, etc.), *see* Table 4.

The alloys are arranged in alphabetical order of the symbols of their constituents.

A superior a prefixed to a conductivity (^aK, ^{a}0.208) denotes that the observations have been adjusted to accord with the conductivities of the pure constituents as given in Table 3.

d = density; l = liquid; s = solid; t', t'' indicate the range over which the temperature formula applies; α, β are the coefficients in the equation

$$K_t = K_{t'}\,[1 + (10)^{-3}\alpha(t - t') + (10)^{-6}\beta(t - t')^2]$$

unless "(K_0)" is written in the $K_{t'}$ column, then $K_t = K_0\,[1 + (10)^{-3}\alpha t + (10)^{-6}\beta t^2]$, α_0 always refers to the equation $K_t = K_0\,(1 + (10)^{-3}\alpha_0 t)$; σ = electrical volume resistivity. Unless otherwise indicated, the composition is expressed in grams of constituent per 100 g of alloy. All temperatures are centigrade.

Unit of K = 1 watt/(cm °C) = 0.2389 cal_{15}/(cm sec °C) = 1.338 × $10^{-3}BTU_{60}$/(in. sec °F); of d = 1 g/cm³.

Ag-Au (100)

Au At. %	Au Wt. %	$^aK_0$	$^aK_{100}$	Au At. %	Au Wt. %	$^aK_0$	$^aK_{100}$
0	0	4.19	4.12	50.9	65.4	0.64	0.92
5.0	8.8	2.33	2.53	55.1	69.2	0.76	0.94
9.7	16.4	1.60	1.69	59.9	73.2	0.71	0.96
14.5	23.6		1.43	70.3	81.3	0.80	0.98
20.0	31.4	0.99	1.28	81.3	88.8	0.98	1.26
30.2	44.2	0.87	1.04	89.3	93.8	1.38	1.62
39.7	52.3	0.78	1.00	95.1	97.3	1.86	2.15
45.4	60.3	0.76	0.97	100.0	100.0	2.96	2.95

Ag-Cd (100)

Cd

At. %	Wt. %	$^aK_0$	$^aK_{100}$
0	0	4.19	4.12
5.7	5.9	1.65	1.92
11.6	12.0	1.05	1.32
19.9	20.5	0.80	0.96
27.7	31.4	0.73	0.92

Ag-Cu (105)

Cu	K_{62}	Cu	K_{62}
0	4.05	50	3.12
5	3.52	55	3.14
15	3.43	60	2.75
25	3.30	70	2.63
35	3.19	80	2.67
40	3.11	90	3.02
45	3.13	95	3.25
47	3.11	100	3.82

Ag-Pb (105)

Pb	K_{60}
0	4.05
10	0.988
20	0.744
30	0.577
40	0.561
50	0.489
60	0.439
70	0.395
80	0.381
90	0.352
100	0.347

Ag-Pd (99)

Pd	$^aK_{25}$	Pd	$^aK_{25}$
0	4.17	60	0.27
10	1.44	70	0.32
20	0.85	80	0.37
30	0.58	90	0.48
40	0.46	100	0.67
50	0.32		

Ag-Pt (99)

Pt	$^aK_{25}$
0	4.17
10	1.00
25	0.39
30	0.31
33	0.30

Ag-Sn (105)

Sn	K_{60}	Sn	K_{60}
0	4.05	60	0.611
10	0.297	70	0.611
20	0.196	80	0.611
27.5	0.393	90	0.602
40	0.490	100	0.632
50	0.577		

Ag-Sn (46)

Sn = 4 %

t =	53.0	75.5
K =	0.55	0.57

Ag-Tl (46)

2.73 %Tl t	2.73 %Tl K	4.76 %Tl t	4.76 %Tl K
23.5	1.58	48.5	1.10
37.5	1.62	88.0	1.15

Ag-Zn (100)

Zn

At. %	Wt. %	$^aK_0$	$^aK_{100}$
0	0	4.19	4.12
4.0	2.5	2.14	2.28
8.8	5.6	1.60	1.81
11.9	7.6	1.49	1.72
16.3	10.5	1.43	1.65

Al-Cd-Cu-Mg-Mn-Zn (22)

"Dow-metal" alloys, sand cast

	a	b	c
Al	8.0	2.0	8.3
Cd	1.0	2.0	1.0
Cu	1.0	3.8	2.0
Mg	90.0	92.0	88.0
Mn		0.2	0.2
Zn			0.5
K_{200}	0.753	1.22	0.737

Al-Cr-Cu-Fe-Si

t = 30° (73)

Cr	Cu	Fe	Si	d
0.87	1.78	0.92	0.38 %	2.74

Annealed 30 min at 450°, K = 1.09; chill cast, K = 1.05.

Al-Cu

Aluminium-bronze (3)

Cu = 90 %; K = 0.753; t = ?

Al-Cu (105); *see also* Al-Mg

Cu	K_{53}	Cu	K_{53}
0	2.11	60	0.753
10	1.61	70	0.744
20	1.45	80	0.293
30	1.30	90	0.316
50	1.06	100	3.85

Al-Cu-Fe-Mg-Mn-Ni-Si-Sn-Zn (73)

t = 30°; K_1, chill cast; K_2, annealed 30 min at 450°C.

$K\sigma$ is approximately same for all these alloys.

Alloy	Cu	Si	Fe	Mn
a		0.137	0.509	
b		11.88	0.80	
c	12.21	0.30	0.62	
d	12.17	0.22	0.64	0.98
e	8.42	0.27	0.70	0.71
f	4.32	0.38	0.87	0.55*
g	8.07	0.38	0.63	Zn
h	2.70	0.39	0.57	12.02
i	2.57	0.37	0.57	20.32

Alloy	d	K_1	K_2
a	2.70	1.86	2.00
b	2.67	1.31	1.78
c	2.93	1.24	1.48
d	2.92	0.93	1.33
e	2.81	1.02	1.35
f	2.78	1.22	1.52
g	2.83	1.39	1.67
h	2.94	1.32	1.33
i	3.20	1.07	1.08

* Also, Mg = 0.42; Zeppelin alloy.

Al-Cu-Fe-Mn-Si-Zn (117)

	a	*b*	*c*	*d*	*e*
Al	99.49	91.17	92.05	91.44	91.33
Cu	0.07	7.61	6.78	7.30	8.04
Fe	0.30	0.56	0.58	0.59	0.63
Mn		0.35	0.36	0.41	
Si	0.30	0.31	0.23	0.23	
Zn	0.07	Tr.	Tr.	0.03	
t	136°	163°	173°	172°	154°
K	1.97	1.38	1.42	1.38	1.46

a = No. 1 commercial hard drawn aluminium.
b = All pig Al, sand cast. *c* = Scrap Al, sand cast.
d = 50% pig Al, 50% scrap Al, sand cast.
e = All pig Al, chill cast.

Al-Cu-Fe-Mn-Sn-Zn (21)

Manganese bronze; high tensile brass

Al	Cu	Fe	Mn	Sn	Zn
0.95	57.14	1.84	2.33	0.26	37.48
t'	*t''*	K_0	α	β	
0	400	0.670	0.72	0.16	

Al-Cu-Sn

Aluminium-bronze (117)

Al	Cu	Sn	*t*	*K*
9.09	89.87	0.47	240	0.73

Al-Mg (22)

"Dow-metal" alloy, sand cast

Mg	K_{200}	Mg	K_{200}
85	0.611	94	0.841
88	0.670	96	0.942
90	0.720	98	1.11
92	0.774	100	1.57

Al-Mg (105)

	a	*b*	*c*	*d*	*e*	*f**
Al	0	4.12	10.12	99.88	97.52	95
Mg	99.95	95.82	89.82	0	0	0.5
Cu				0.027	0.48	4
Fe	0.028	0.028	0.028	0.030	0.66	
Mn					1.07	0.5
Si	0.014	0.019	0.023	0.059	0.27	
K_{53}	1.50	0.665	0.485	2.09	1.69	1.85

* Composition approximately as given.

Al-Mg-Mn (22)

"Dow-metal" alloy; sand cast

Al	Mg	Mn	K_{200}
5.8	94.0	0.2	0.845

Al-Sb (105)

Sb	K_{52}	Sb	K_{52}
0	2.11	60	0.477
10	1.84	70	0.418
20	1.59	80	0.218
30	1.41	90	0.243
40	1.00	100	0.201
50	0.807		

Al-Sn (105)

Sn	K_{51}	Sn	K_{51}
0	2.11	70	1.14
10	1.86	80	0.950
30	1.73	90	0.811
50	1.39	100	0.628
60	1.25		

Al-Zn (105)

Zn	K_{50}
0	2.11
10	1.62
20	1.36
30	1.32
60	1.19
100	1.16

Au-Cd (100)

Cd

At. %	Wt. %	$^aK_0$	$^aK_{100}$
0	0	2.96	2.95
5.4	3.1	1.24	1.48
8.7	5.1	0.96	1.17
17.2	10.6	0.72	0.80

Au-Cu (100)

Cu

At. %	Wt. %	$^aK_0$	$^aK_{100}$
0	0	2.96	2.95
9.5	3.3	1.10	1.35
20.0	7.4	0.68	0.80
30.2	12.2	0.58	0.69
68.1	30.7	0.59	0.63
79.3	55.3	0.69	0.72
89.6	73.5	1.04	1.28
100	100	3.88	3.83

Au-Pd

t = 25°C (99)

Pd	^aK	Pd	^aK	Pd	^aK
0	2.96	40	0.38	80	0.41
10	0.92	50	0.35	90	0.52
20	0.56	60	0.35	100	0.67
30	0.42	70	0.39		

Au-Pt

t = 25°C (99)

Pt	^aK
0	2.96
10	0.69
20	0.38
30	0.28
40	0.24

Au-Zn (99)

Zn

At. %	Wt. %	$^aK_0$	$^aK_{100}$
0	0	2.96	2.95
4.9	3.0	1.18	1.33
10.1	6.5	0.67	0.81

Bi-Cd (105)

Cd	K_{55}
0	0.079
10	0.129
20	0.163
30	0.209
40	0.251
50	0.339
60	0.393
70	0.489
80	0.597
90	0.720
100	0.941

Bi-Cd-Pb-Sn

	Bi	Cd	Pb	Sn	*t*	K_t
*a**	48	13	26	13	7	0.133
b†	50	11	25	14	0	0.184

* *a* = Wood's alloy, melts 70°C (110); *b* = Lipowitz's alloy, melts 65°C (67).
† α_0 = 0.268 if 18° ≥ *t* ≥ −170°C.

Bi-Pb

t = ?; Volume % (98)

Pb	*K*
0	0.0778
0.43	0.0787
0.76	0.0725
1.53	0.0540
1.65	0.0498
2.69	0.0490
3.53	0.0540
8.53	0.0765
42.30	0.122
74.77	0.196

Bi-Pb.—(*Continued*)

Pb	*K*
94.41	0.310
100	0.335

Pb = 46% (weight) (16)

t'	*t''*	$K_{t'}$	α
0	130	0.100	−0.48 *s*
130	300	0.90	+1.2 *l*

Bi-Pb-Sn

Rose's metal (114)

Bi	Pb	Sn	*t*	K_t
50	25	25	12.5	0.167

Bi-Sb

(*a*) Cast metal (30)

Values of 1000 ^aK

% Sb	−190°	−77°	0°	100°
0	214	89	83.7	80
9	55	49	54	58
11	41	36	44	62
13	45	42	52	66
20	46	44	53	71
50	60	61	68	80
70	71	76	81	97
100	367	218	186	179

(*b*) Pressed powders (30)

Value of 1000 *K*, pressure = 5000 kg/cm²

% Sb	−190°	−80°	0°	100°
0	208		81	51
5	58		60	67
7			49	57
11	160		90	65
13	93		88	81
100		137	121	105

Bi-Sn (117)

t = 12.5 (98)

Sn	*K*
33.3	0.096
50.0	0.234
66.7	0.423
100	0.636
0*	0.0795
0.46*	0.0585
0.95*	0.0527

Bi-Sn.—(*Continued*)

Sn*	*K*
2.87	0.0460
9.74	0.0527
23.87	0.117
50.10	0.209
75.07	0.368
95.73	0.561
100	0.627

* Volume %; *t* = ?

Cd-Hg [46]

Hg	t	K
5.14	56	0.84
5.14	95	0.83
10	64	0.72
10	82.5	0.71

Cd-Sb [24]

Values of ^{a}K

Sb	−190°	−70°	0°
0	0.113	0.933	0.933
33.3	0.139	0.118	0.112
50	0.055	0.276	0.0226
51.7*	0.386	0.214	0.0138
66.7	0.272	0.179	0.0136
100	0.290	0.218	0.186

*Equimolecular.

Cd-Sn [105]

Sn	K_{63}
0	0.942
10	0.875
20	0.837
30	0.783
40	0.754
50	0.699
60	0.653
70	0.645
80	0.594
90	0.557
95	0.536
100	0.628

Cd-Tl [105]

Tl	K_{63}
0	0.970
10	0.865
20	0.799
30	0.754
40	0.703
50	0.662
60	0.582
70	0.535
80	0.494
90	0.444
100	0.440

Cd-Zn [105]

Zn	K_{63}
0	0.941
10	0.954
20	0.966
30	0.996
40	1.02
60	1.04
70	1.07
80	1.09
95	1.13
100	1.16

Co-Cr [105]

Cr	K_{59}
0	0.490
10	0.142
30	0.130
40	0.105

Co-Fe [51]

Cobalt iron

Wt. % of impurities in "Fe" = 0.09 C, 0.288 Cu, 0.31 Mn, 0.03 P, 0.026 S, 0.11 Si; in "Co" = 0.24 C, 1.4 Fe, 1.1 Ni, 0.14 Si.

Co	K_{30}
0	0.457
5	0.402
10	0.395
15	0.409
20	0.438
30	0.503
40	0.599
50	0.712
70	0.721
80	0.512
90	0.402
100	0.692

Similar curves found for other properties.

Cr-Fe

Chromium steels [75]

Annealed from 900°C

Cr	K
0	0.418
0.5	0.416
1	0.402
2	0.400
3	0.374
5	0.305
10	0.218
15	0.186
20	0.179
Quenched at 1100°C	
0	0.410
0.5	0.371
1	0.369
2	0.364
3	0.291
5	0.186
8.5	0.162
13	0.140
17	0.130

See Fig. 1.

Cr-Ni [105]

Ni	K_{56}
50	0.117
60	0.126
70	0.109
90	0.197
100	0.586

Cu-As-Ni-Sb [21]

Arsenical copper; Pb, Sn = 0

Cu	As	Ni	Sb	K_0
99.530	0.389	0.022	0.003	2.13

$\alpha_0 = 0.088$ if $0° \leq t \leq 400°$.

Cu-Fe-Pb-Sn-Zn [21]

a = Phosphor bronze, b = Admiralty gun-metal, c = Ordinary gun-metal, d = 70:30 Brass, e = Monel metal, f = White bearing metal.

	Cu	Fe	Pb	Sn	Zn
a*	87.82	0.17	Tr.	11.28	Tr.
b	87.24	0.21	0.35	10.02	2.18
c	85.05	0.21	0.98	8.72	5.04
d	70.29	0.31	0.34	0.35	28.71
e†	29.07	2.68	0.84	67.05	
f‡	4.00	0.14	0.12		87.80

* a contains 0.35 P. † e contains 0.30 Si. ‡ f contains 7.73 Sb.

	t'	t''	K_0	α	β
a	0	400	0.481	1.2	0
b	0	400	0.544	0.98	−0.48
c	0	400	0.682	0.49	−0.15
d	0	400	0.963	0.87	−0.87
e	0	400	0.239	2.3	−2.8
f	0	200	0.259	3.1	0

Cu-Mn-Ni, Manganin

Cu = 84, Mn = 12, Ni = 4%

t'	t''	$K_{t'}$	α	β	Lit.
0	100	0.208*	+2.7		(57, 67)
0	−170	^{a}0.208	+2.65	+4.5	(67)

* $K_0 = 0.208 \pm 0.005$.

Cu-Mg [22]

"Dow-metal" alloy; sand cast

Mg	K_{200}
96.0	0.325

Cu-Mn [105]

Mn	K_{59}
0	3.84
10	0.272
20	0.171
30	0.134
40	0.130
60	0.113
80	0.105

Cu-Ni [105]

Ni	K_{57}
10	0.389
30	0.242
40	0.226
50	0.226
60	0.226
70	0.289
80	0.306
100	0.586

Cu-Ni

Eureka, Constantan, etc.

Ni	t	K_t	Lit.
3.94	38.5	0.89	(46)
3.94	56.5	0.91	(46)
17.3	53.5	0.37	(46)
17.3	75	0.39	(46)
46	18	0.202	(36)

Ni [100]

At. %	Wt. %	$^{a}K_0$	$^{a}K_{100}$
0	0	3.88	3.83
5.4	5.0	1.02	1.20
10.8	10.0	0.61	0.87
21.4	20.0	0.36	0.46
41.9*	40.0	0.22	0.29
62.8	60.9	0.24	0.28
82.8	81.6	0.27	0.27
100	100	0.59	0.57

* Eureka, Constantan; $K_0 = 0.218 \pm 0.005$ ([6, 8, 57]); *cf.* [3]; if $0° < t < 100°$, $\alpha_0 = +2.4$ [57], $\alpha_0 = +0.7$ [6].

Cu-Ni-Sn-Zn

"Rotguss" [57]

Cu	Ni	Sn	Zn
85.7	0.58	6.39	7.15
t'	t''	$K_{t'}$	α
0	100	0.572	2.4

Cu-Ni-Zn

German silver [67]

Cu = 62, Ni = 15, Zn = 22

t'	t''	$K_{t'}$	α	β
0	100	0.239*	2.7	
18	−170	($^{a}K_0$)	1.8	1.95
0	−170	0.243†	2.7	4.5

* $K_0 = 0.239 \pm 0.015$ ([67, 70, 115]); *cf.* ([34, 79, 111]), $\alpha_0 = 2.7$ [70].

† Platinoid, approximately same composition as German silver [67].

Cu-Pb-Sb-Sn-Zn

"S. A. E. bearing alloys" [117]

	Cu	Pb	Sn	Sb
a	3.58	0.19	92.49	3.74
b	5.16	0.12	86.92	7.9
c	7.07	63.94		28.84
d*	79.04	9.55	10.83	

* Also 0.30 % P.

Cu-Pb-Sb-Sn-Zn.—(*Cont'd*)

	Cu	Pb	Sn	Zn
e	84.93	5.01	5.14	4.92
f	86.60	0.04	10.55	2.81
g	85.29	8.26	5.56	0.89

	K_{75}		t	K_t
a	0.385	*d*	245	0.456
b	0.260	*e*	232	0.962
c	0.318	*f*	247	0.585
		g	230	0.741

Cu-Sn, 5 % Sn (46)

$K_{48} = 0.77$; $K_{91.5} = 0.83$

Cu-Zn (100)

Zn

At. %	Wt. %	$^aK_0$	$^aK_{100}$
0	0	3.88	3.83
7.1	7.3	2.11	2.29
14.0	14.3	1.55	1.70
27.3	27.8	1.29	1.45
32.4	33.0	1.21	1.39

% Zn (46)	t	K_t
3.1	41.5	2.74
3.1	73	2.76
5	38	2.13
5	75.5	2.09

% Zn (114)	K_{18}
11	1.14
13	1.25
18	1.30
32	1.08

Zn = 18 %; A = mean area of crystals, unit = 1 mm² (25)

A	K_{-183}	K_0
0.6	0.660	1.270
11	0.650	1.295

Brass, Zn = 30 %

t'	t''	$K_{t'}$	α	Lit.
0	100	1.05*	+1.5	(70)
0	−75	^{a}1.05	+1.47	(67)
−75	−170	^{a}0.94	+2.34	(67)

Yellow brass, $K_0 = 0.855$ (70)

Red brass, $K_0 = 1.03$ (70)

* $K_0 = 1.05 \pm 0.05$ (12, 26, 67, 70, 114); *cf.* (4, 34).

Fe-Mn

Manganese steels (74); *cf.* (98)

Wt. % of other substances in "Mn" = 1.90 Al, 0.07 C, 0.24 Fe, 0.46 Si; in "Fe" = 0.206 C, 0.114 Mn, 0.05 P, 0.04 S, 0.06 Si. Points of inflection near "Mn" = 1 %, they exist also in curves representing other properties of these steels.

% "Mn"	K_{30}
0.11	0.544
0.31	0.468
0.6	0.422
0.8	0.399
1.1	0.412
1.6	0.356
2.0	0.316
3.0	0.260
5.0	0.184
7.9	0.155
8.8	0.147
9.8	0.148

Fe-Ni (56); *cf.* (3)

Nickel-iron, Invar, etc.

% Ni	K_{65}
0	0.597*
1	0.445
2	0.422
5	0.352
10	0.289
15	0.220
20	0.209
25	0.138
30	0.118
35†	0.110
45	0.146
75	0.289
100	0.586*

* (57).

† Invar (Fe_2Ni) contains about 35 % Ni. Other properties also have maximum or minimum at Ni = 30 to 40 %

Nickel steel (Krupp) (58)

Ni = 30.4, Mn = 0.84, Cu = 0.26, Si = 0.14 % (weight)

Heat treatment	K_{26}
Forged	0.121*
Annealed: 700°, 3 hr	0.119
Cooled:†	
−26°, 2 hr and −29°, 1 hr	0.120
−70°, 7 hr; −76°, 4 hr; −78°, 2 hr	0.120
−165°, 3 hr and −185°, 1 hr	0.124

* $K_0 = 0.116$; $26° \leq t \leq 71.5°$, $\alpha_0 = 1.78$.

† Cooled for successive and consecutive periods to temperatures below those indicated; *e.g.*, in fourth case the specimen was cooled below −70°C for 7 hr, below −76°C for 4 hr, and below −78°C for 2 hr, a total of 13 hr.

Nickel steels (50)

Alloys of low carbon steel and commercial nickel. Wt. % of impurities of steel = 0.09 C, 0.288 Cu, 0.31 Mn, 0.03 P, 0.26 S, 0.11 Si; of Ni = 0.29 C, 4.2 Cu, 1.25 Fe, 0.35 Mn, 0.17 S, 0.15 Si.

"Ni,"	1000 K_{30}	
Wt. %	A*	C†
0	410	410
5	320	302
10	258	255
15	218	214
20	175	192
23	171	188
25	130	192
30	83	188
31.5	78	157
33	81	134
35.5	81	
40	86	
60	151	
80	236	
90	304	
100	349	

* Annealed from 900°C.

† Precooled to −190°C.

Ferro-nickel (3)

Ni = 25, C = 0.27 % (weight); $K_t = 0.181$, t = ?

Fe-W

Tungsten steel, (52); *cf.* Fig. 2

% C =	0.3	0.6	0.6
	A*	A*	Q†
% W	1000 K		
0	457	422	
0.5	419	374	
1	411	360	343
2	402	350	
3		356	280
5	390		
6	387	356	238
10		332	
15	324	309	
20	270	276	182
25	221	231	167

* Annealed from 900°C.

† Quenched at 1100°C.

Ir-Pt (6)

% Pt	K_{17}	K_{100}
0	0.590	0.565
80	0.176	0.176
85	0.234	0.247
90	0.310	0.314
100	0.690	0.711

K-Na (54)

Equi-atomic mixture

t	K_t
−15	0.296 *s*
−10	0.292 *s*
+ 5	0.229 *l*
20	0.243 *l*
30	0.249 *l*
40	0.257 *l*

Mn-Ni (105)

Ni	K_{60}
10	0.092
30	0.105
40	0.096
50	0.092
70	0.155
80	0.176
90	0.310
100	0.585

Pb-Sb (105)

Sb	K_{54}
0	0.347
10	0.263
20	0.230
30	0.218
40	0.213
50	0.202
60	0.202
70	0.197
80	0.188
90	0.202
100	0.202

Pb-Sb

Pb = 87, Sb = 13 (16)

t'	t''	$K_{t'}$	α
0	248	0.268	+0.25 *s*
248	380	0.130	+3.66 *l*

Pb-Sn (105)

Sn	K_{54}
0	0.348
10	0.360
20	0.372
30	0.385
40	0.414
50	0.465
60	0.489
80	0.544
100	0.632

Pb-Sn

Pb = 38, Sn = 62 (16)

t'	t''	$K_{t'}$	α
0	180	0.506	−0.56 *s*
180	420	0.209	+1.67 *l*

Pb-Tl (105)

Tl	K_{63}
0	0.347
10	0.284
20	0.251
30	0.226
40	0.201
50	0.201
60	0.226
70	0.259
80	0.322
90	0.376
94	0.402
96	0.364
98	0.385
100	0.440

Pd-Pt [99]

Pt	K_{25}
0	0.67
10	0.56
20	0.44
30	0.40
40	0.38
50	0.37
60	0.34
70	0.36
80	0.42
90	0.43
100	0.70

Pt-Rh [6]

Rh	K_{17}	K_{100}
0	0.690	0.711
10	0.302	0.306

Sb-Sn [105]

Sn	K_{57}
0	0.201
10	0.188
20	0.176
30	0.197
40	0.213
50	0.268
60	0.306
70	0.352
80	0.398
100	0.628

Sn-Zn, t = ? [98]

Zn, Vol. %	$K_?$
0	1.045
29.81	0.933
46.17	0.886
63.05	0.779
76.66	0.745
87.22	0.674
91.07	0.657
100	0.628

Sn = 92, Zn = 8 [16]

t'	t''	$K_{t'}$	α
0	200	0.590	+0.425 s
200	440	0.230	+2.5 l

Tl-Sn [105]

Sn	K_{63}
0	0.439
10	0.301
20	0.255
30	0.259
40	0.289
46.6	0.330
50	0.372
53.8	0.385
60	0.418
70	0.436
80	0.486
90	0.557
100	0.632

LITERATURE

(For a key to the periodicals see end of volume)

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(30) Gehlhoff and Neumeier, *26*, **15**: 876; 13. (31) Gehlhoff and Neumeier, *26*, **15**: 1069; 13. (32) Gehlhoff and Neumeier, *26*, **21**: 201; 19. (33) Giebe, *26*, **5**: 60; 03. *Diss.*, Berlin, 1903. (34) Glage, *8*, **18**: 904; 05. (35) Gray, *62*, **186**: 165; 95. (36) Grüneisen, *8*, **3**: 43; 00. (37) Grünzweig, *92*, **27**: 223; 14. (38) Hall, *65*, **27**: 262; 92. (39) Hall, *65*, **31**: 271; 96.

(40) Hall, *2*, **10**: 277; 00. (41) Hall, *2*, **11**: 329; 18. (42) Hall, *2*, **19**: 237; 22. (43) Hall and Ayres, *65*, **34**: 281; 99. (44) Hall, Hull and Imdoff, *2*, **18**: 326; 21. (45) Hansen, *78*, **16**: 329; 09. (46) Hardebeck, *Diss.*, Aachen, 1909. (47) Hering, *129*, **29**: 485; 10. (48) Herwig, *8*, **151**: 177; 74. (49) Hevesy, *96*, **10**: 84; 22.

(50) Honda, *159*, **7**: 59; 18. (51) Honda, *159*, **8**: 51; 19. (52) Honda and Matushita, *159*, **8**: 89; 19. (53) Honda and Simidu, *159*, **6**: 219; 17. (54) Hornbeck, *2*, **2**: 217; 13. (55) Icole, *6*, **25**: 37; 12. (56) Ingersoll *et al.*, *2*, **16**: 126; 20. (57) Jaeger and Diesselhorst, *89*, **3**: 269; 00. (58) Jakob, *98*, **66**: 688; 22. (59) Johnstone, *67*, **29**: 195; 17.

(60) Kaye and Roberts, *5*, **104**: 98; 23. (61) King, *2*, **6**: 437; 15. (62) King, *2*, **11**: 149; 18. (63) Kirchhoff and Hansemann, *8*, **9**: 1; 80. **13**: 406; 81. (64) Kohlrausch, *8*, **33**: 678; 88. *3*, **25**: 448; 88. (65) Konno, *159*, **8**: 169; 19. *3*, **40**: 542; 20. (66) Langmuir, *2*, **7**: 151; 16. (67) Lees, *62*, **208**: 381; 08. (68) Lees and Calthrop, *67*, **35**: 225; 23. (69) Lorberg, *8*, **14**: 291, 426; 81.

(70) Lorenz, *8*, **147**: 429; 72. **13**: 422, 582; 81. (71) Lussana, *59*, **7**: 333; 98 **15**: 130; 18. **25**: 115; 23. (72) Macchia, *22*, **16 I**: 507; 07. (73) Masumoto, *159*, **13**: 229; 25. (74) Matushita, *159*, **8**: 79; 19. (75) Matushita, *159*, **9**: 243; 20. (76) Meissner, *26*, **16**: 262; 14. (77) Meissner, *8*, **47**: 1001; 15. (78) Meissner, *96*, **2**: 373; 20. (79) Mitchell, *174*, **33**: 535; 88.

(80) Nettleton, *3*, **19**: 587; 10. (81) Nettleton, *67*, **26**: 28; 13. (82) Nettleton, *67*, **27**: 129; 15. (83) Neumann, *6*, **66**: 183; 62. *3*, **25**: 63; 63. (84) Northrupp and Pratt, *143*, **184**: 675; 17. (85) O'Day, *2*, **23**: 245; 24. (86) Onnes and Holst, *64P*, **17**: 760; 14. *168*, No. **142c**. (87) Ott, *414*, No. **35**: 53; 06. *98*, **51**: 1145; 07. (88) Peczalski, *Thesis*, Paris, 1916. *34*, **160**: 766; 15. (89) Pfleiderer, *Ges. Abhandl. Kennt. Kohle*, **4**: 409; 19.

(90) Porter and Simeon, *67*, **27**: 307; 14. (91) Quick and Lamphear, *2*, **3**: 1; 95. (92) Reitzsch, *8*, **3**: 403; 00. (92.5) Riecke, *8*, **66**: 353, 545; 98. (93) Schaufelberger, *8*, **7**: 589; 02. (94) Schenck, *8*, **32**: 261; 10. (95) Schofield, *5*, **107**: 206; 25. (96) Schott, *26*, **18**: 27; 16. (97) Schulze, *8*, **63**: 23; 97. (98) Schulze, *Diss.*, Marburg, 1902. *8*, **9**: 555; 02. (99) Schulze, *26*, **13**: 856; 11.

(100) Sedström, *8*, **59**: 134; 19. **75**: 549; 24. *Diss.*, Stockholm, 1924. (101) Sieg, *2*, **6**: 213; 15. (102) Simidu, *159*, **6**: 111; 17. (103) Smith, *2*, **28**: 107; 09. (104) Smith, *2*, **28**: 429; 09. (105) Smith, *Ohio State Univ., Eng. Exper. Bull.*, **2**: No. 7; 25. (106) Taylor, *108*, **75**: 1054; 19. (107) Taylor, *107*, **76**: 1159; 20. (108) Tesche, *97*, **5**: 233; 24. (109) Weber, *8*, **146**: 257; 72. *3*, **44**: 481; 72.

(110) Weber, *Monatsber. Berlin Akad.*, **1880**: 457. (111) Weber, *8*, **10**: 472, 80. (112) Weber, *8*, **11**: 1047; 03. (113) Weber, *8*, **54**: 165; 17. (114) Wiedemann, *8*, **108**: 393; 59. *6*, **58**: 126; 60. *3*, **19**: 243; 60. (115) Wiedemann and Franz, *8*, **89**: 497; 53. *6*, **41**: 107; 54. *3*, **7**: 23; 54. (116) Williams, *33*, **26**: 739; 22. (117) Williams and Bihlman, *80*, **69**: 1065; 23. (118) Wold, *2*, **7**: 169; 16. (119) Worthing, *2*, **4**: 535; 14.

(120) Worthing, *2*, **10**: 377; 17.

NON-METALLIC LIQUIDS

For glasses, *see* p. 229 and Vol. II, p. 315

The data pertaining to the thermal conductivity (K) of liquids are of such a character that it is very difficult to determine from them the correct value of K, and its temperature coefficient for any liquid. The data for water are the best; for the temperature coefficients of other liquids we rely almost exclusively upon a single observer (4). For only 16 liquids (Table 10-I, p. 227) is it possible either to set useful limits between which K probably lies, or to determine a reliable value for the temperature coefficient of K. Having decided upon the values for these liquids the data for other liquids which have been determined relatively to these are adjusted accordingly. Similarly, in estimating a value of K for a liquid which has been studied by a single observer, his data are modified in accordance with the way in which his data for liquids which had been studied by others departed from what seemed to be the appropriate values. The grade of the observations, or the degree of confidence with which the data here given should be accepted is indicated qualitatively by the letters A, B, C, D. A denotes a pronounced consensus of opinion; B that the value is supported by at least one strong observer; and D, that no great confidence should be placed in the value.

Several expressions relating K to other properties of the liquid have been proposed. Some, such as $K < c\eta$, are inequalities which seem to be too pronounced to be of practical value (15). An equality, which was early proposed, is $\frac{K}{dc}\left(\frac{M}{d}\right)^{1/3} = \text{constant}$, where c = specific heat, d = density, M = molecular weight. In the absence of reliable data for K and c, it is not known whether the relation is valid (1, 14, 34, 35). A third relation, involving (v) the velocity of sound and e_0 (= translational energy of a molecule of ideal gas at 1°K) is $K = 2e_0v/\delta^2$, where δ = mean distance between centers of adjacent molecules. Taking $\delta = (m/d)^{1/3}$, where m = mass of one molecule, results approximating closely to those observed are obtained, *see* Table 6.

TABLE 6.—COMPARISON OF OBSERVED (K) WITH COMPUTED (K_c) CONDUCTIVITY (4)

$K_c \equiv 2e_0 v(d/m)^{\frac{2}{3}}$

Unit of $v = 10^5$ cm/sec; of $(d/m)^{\frac{2}{3}} = 10^{14}$ cm^{-2}; of K, $K_c = 10^{-5}$ watt/(cm °C); $t = 30$°C.

Formula	Substance	v	$(d/m)^{\frac{2}{3}}$	K_c	K
H_2O	Water	1.50	10.4	630	601
CS_2	Carbon disulfide	1.18	4.61	219	159
CH_4O	Methyl alcohol	1.13	6.00	274	211
C_2H_5Br	Ethyl bromide	0.90	3.97	145	120
C_2H_5I	Ethyl iodide	0.78	3.81	121	111
C_2H_6O	Ethyl alcohol	1.14	4.74	218	180
C_3H_6O	Acetone	1.14	4.00	185	179
C_3H_8O	Propyl alcohol*	1.24	3.94	197	154
$C_4H_{10}O$	Butyl alcohol*	1.05	3.49	149	167
$C_4H_{10}O$	Ethyl ether	0.92	3.19	119	137
$C_5H_{12}O$	Isoamyl alcohol	1.24	3.13	157	148

* K_c computed for n-propyl and isobutyl alcohols, and K observed for isopropyl and n-butyl alcohols.

Two formulae have been proposed for computing the conductivity of a binary liquid mixture. One (21) is $(v_1 + v_2)K^n = v_1K_1^n + v_2K_2^n$, where v_1, v_2 are the volumes of the pure constituents and n is a constant which depends upon the constituents. The other, proposed by the compilers, is new and is easy to use if a table of hyperbolic sines is available, *v.* (3, 28, 29). It is $K \sinh 100\mu = K_1 \sinh p_1\mu + K_2 \sinh p_2\mu$, where p_1 and p_2 are the percentages, by weight, of the constituents and μ depends upon the constituents, and the temperature. Satisfactory data for testing the formula are available for only 6 mixtures, for these it fits well within the limits of experimental error; for values of μ, *see* Table 7.

TABLE 7.—THERMAL CONDUCTIVITY OF BINARY LIQUID MIXTURES AT 20°C (12, 20, 21)

$K \sinh (100\mu) = K_1 \sinh p_1\mu + K_2 \sinh p_2\mu$; G = degree of confidence (*see* p. 226).

Constituents	$100\mu_{20°}$	G
Water-ethyl alcohol	1.34	B
Water-methyl alcohol	1.30	B
Water-glycerol	0.40	C
Water-acetic acid	0.90	C
Methyl alcohol-ethyl alcohol	0.48	B
Glycerol-ethyl alcohol	0.98	B

In general the formula $K = K_w(1 - \alpha p)$ represents the conductivity of aqueous solutions, p = grams of solute per 100 g of solution, K_w = conductivity of pure water at the same temperature, and α(= depression coefficient) is a constant depending upon the solute and probably upon the temperature. In certain cases (notably HCl) the linear relation is not applicable, and for some dilute solutions one observer finds $K > K_w$ and increases with the concentration (*see* Table 8); additional observations are desirable. For aqueous solutions containing two solutes, in general, $\alpha p = \alpha_1 p_1 + \alpha_2 p_2$. (*See* Table 11.)

TABLE 8.—ILLUSTRATING EXCEPTIONAL VARIATION OF THERMAL CONDUCTIVITY WITH CONCENTRATION: AQUEOUS SOLUTIONS (18)

For these solutions $K > K_w$ and increases with the concentration (C). Accuracy very low, degree of confidence = D.

Unit of $C = 1$ g-equiv./liter; of $K = 10^{-5}$ watt/(cm °C); tabular values are K; $t = 9$°C.

Solute \ C	0	0.0001	0.001	0.01	0.1	1
$C_2HCl_3O_2$, trichloroacetic acid	510	518	611	678	725	810
H_3BO_3, boric acid	510	513	519	563	584	
KCl,* potassium chloride	510	511	565	637	726	740

* Data at variance with those of other observers, *cf.* Table 11.

TABLE 9.—THERMAL CONDUCTIVITY OF LIQUIDS UNDER PRESSURE (4)

Quantity tabulated is $r_t \equiv 1000\ K_p/K_a$ where K_p = conductivity at temperature t and pressure P, and K_a = conductivity at temperature t and 1 atm.

Unit of $P = 1000$ kg/cm^2 = 967.8 atmosphere = 14 223 lb./in^2; grade = C (*v.* p. 226).

Formula	Substance \ P	2	4	6	8	10	12	t
H_2O	Water	1113	1210	1293	1366	1428	F*	30
CS_2	Carbon disulfide	1310	1512	1663	1783	1880	1962	30
CH_4O	Methyl alcohol	1342	1557	1724	1864	1986	2097	30
C_2H_5Br	Ethyl bromide	1327	1517	1657	1768	1858	1928	30
C_2H_5I	Ethyl iodide	1232	1394	1509	1592	1662	1724	30
C_2H_6O	Ethyl alcohol	1363	1574	1744	1888	2014	2122	30
C_3H_6O	Acetone	1315	1511	1659	1786	1900	F*	30
C_3H_8O	Isopropyl alcohol	1352	1570	1743	1894	2028	2150	30
$C_4H_{10}O$	n-Butyl alcohol	1307	1495	1648	1780	1900	2008	30
$C_4H_{10}O$	Ether	1509	1800	2009	2177	2322	2451	30
C_5H_{12}	n-Pentane	1483	1777	1987	2163	2325	2481	30
$C_5H_{12}O$	Isoamyl alcohol	1320	1524	1686	1828	1955	2069	30
C_7H_8	Toluene	1286	1470	1604	1716	F*		30
	Petroleum ether	1460	1752	1970	2143	2279	2379	30
H_2O	Water	1123	1225	1308	1379	1445	1506	75
CS_2	Carbon disulfide	1366	1607	1789	1935	2054	2154	75†
CH_4O	Methyl alcohol	1365	1601	1785	1939	2072	2191	75†
C_2H_5Br	Ethyl bromide	1390	1609	1772	1907	2022	2121	75†
C_2H_5I	Ethyl iodide	1265	1442	1570	1671	1757	1837	75
C_2H_6O	Ethyl alcohol	1400	1650	1845	2007	2152	2278	75†
C_3H_6O	Acetone	1325	1554	1738	1891	2024	2137	75†
C_3H_8O	Isopropyl alcohol	1399	1638	1812	1962	2093	2211	75
$C_4H_{10}O$	n-Butyl alcohol	1358	1559	1720	1859	1985	2099	75
$C_4H_{10}O$	Ether	1518	1814	2043	2231	2394	2537	75†
C_5H_{12}	n-Pentane	1534	1855	2112	2335	2543	2740	75†
$C_5H_{12}O$	Isoamyl alcohol	1348	1557	1724	1868	1998	2126	75
C_7H_8	Toluene	1355	1573	1738	1872	1987	2089	75
	Petroleum ether	1466	1780	2026	2232	2409	2561	75†
	Kerosene	1314	1502	1654	1792	1925	2054	75

* Freezes under this pressure.

† Boils at 75°C and 1 atmosphere, but liquid at pressure of a few 100 kg cm^2; K_a obtained by extrapolating the (K_p, P) graph.

TABLE 10.—THERMAL CONDUCTIVITY (K) OF PURE AND OF MISCELLANEOUS LIQUIDS

For conductivity of solutions, *see* Table 11; of binary mixtures, *see* Table 7

Section I contains all liquids for which the data are of grade A or B; *see* p. 226; Section II contains pure organic liquids, grades C and D; Section III contains miscellaneous liquids. For change in K on fusion, *see* C_7H_9N, $C_{10}H_9N$, $C_{10}H_{14}O$, $CaCl_2.6H_2O$, $Na_2HPO_4.12H_2O$.

$K_t = K_{20}[1 + \alpha(t - 20)]$, $0° < t < 80$°C; the true value of K_{20} is believed to lie between "Min." and "Max." G = grade of the data; t = centigrade temperatures; M. P. = melting point, °C. Only for liquids in Section I are values of "Min.," "Max." and α given. s = solid; l = liquid.

Unit of $K = 10^{-5}$ watt/(cm °C) = 100 erg/(cm sec °C) = 2.389×10^{-6} cal$_{15}$/(cm sec °C); of $\alpha = (1°C)^{-1}$.

I. Liquids: grades A and B (*v.* p. 226)

Formula	Substance	K_{20}	Min.	Max.	1000α	G	Lit.
H_2O	Water	587	580	595	+2.81	A	(4, 14, 16, 20, 25, 35); *cf.* (6, 7, 10, 18, 22, 23, 32, 34, 36)
CS_2	Carbon disulfide	161	145	175	−1.18	B	(4, 9, 35); *cf.* (6, 10, 34)
CH_4O	Methyl alcohol	209	200	220	−0.53	A	(4, 9, 20, 35); *cf.* (6, 11)

TABLE. 10—(*Continued*)

Formula	Substance	K_{20}	Min.	Max.	1000α	G	Lit.
C_2H_6O	Ethyl alcohol	182	172	190	−0.71	*A*	(4, 12, 16, 20, 35); *cf.* (6, 7, 10, 11, 23, 34)
C_2H_5Br	Ethyl bromide	121	100	130	−0.99	*B*	(4); *cf.* (35)
C_2H_5I	Ethyl iodide	111	90	120	−0.33	*B*	(4); *cf.* (35)
C_3H_6O	Acetone	179	160	190	−1.34	*B*	(4, 9)
C_3H_8O	Isopropyl alcohol	153	140	170	−0.24	*B*	(4, 9)
$C_3H_8O_3$	Glycerol	290	275	310	+2.62	*A*	(9, 20, 31, 35, 36); *cf.* (7, 10, 22, 23, 34)
$C_4H_{10}O$	*n*-Butyl alcohol	168	140	200	−0.50	*B*	(4)
$C_4H_{10}O$	Ether	138	120	145	−0.47	*B*	(4, 9); *cf.* (10, 34, 35)
C_5H_{12}	*n*-Pentane	136	110	150	−1.03	*B*	(4); *cf.* (9)
$C_5H_{12}O$	Isoamyl alcohol	148	120	160	−0.38	*B*	(4); *cf.* (11, 35)
C_7H_8	Toluene	160	140	190	−1.44	*B*	(4, 9, 17, 30, 35)
	Petroleum ether	131	120	160	−0.71	*B*	(4); *cf.* (10, 36)
	Kerosene	151	130	170	−1.46	*B*	(4); *cf.* (6, 36)

II. Pure organic liquids: grades *C* and *D* (*v.* p. 226)

Formula	Substance	t	K_t	G	Lit.
CCl_4	Carbon tetrachloride	0	110	*C*	(9); *cf.* (35)
C_2Cl_4	Tetrachloroethylene	22	126	*C*	(30)
$CHCl_3$	Chloroform	12	138	*D*	(34, 35)
CH_2O_2	Formic acid	12	271	*D*	(35)
$C_2H_4Br_2$	1, 2-Dibromoethane	21	118	*C*	(30)
$C_2H_4Cl_2$	1, 2-Dichloroethane	20	158	*C*	(30)
$C_2H_4O_2$	Acetic acid	20	172	*C*	(20, 35)
$C_2H_6O_2$	Glycol	0	265	*C*	(9)
C_3H_6O	Acetone	20	179	*B*	(4, 9)
$C_3H_6O_2$	Ethyl formate	12	169	*D*	(35)
$C_3H_6O_2$	Methyl acetate	12	171	*D*	(35); *cf.* (11)
$C_3H_6O_2$	Propionic acid	12	173	*D*	(35)
C_3H_7Br	Propyl bromide	12	126	*D*	(35)
C_3H_7Cl	Propyl chloride	12	136	*D*	(35)
C_3H_7I	Propyl iodide	12	111	*D*	(35)
C_3H_8O	Propyl alcohol	0	167	*C*	(9); *cf.* (35)
C_4H_5NS	Allyl isothiocyanate	12	170	*D*	(35)
$C_4H_8O_2$	*n*-Butyric acid	12	163	*D*	(35)
$C_4H_8O_2$	Isobutyric acid	12	157	*D*	(35)
$C_4H_8O_2$	Ethyl acetate	19	174	*C*	(30); *cf.* (11, 35)
$C_4H_8O_2$	Propyl formate	12	162	*D*	(35)
C_4H_9Br	Isobutyl bromide	12	134	*D*	(35)
C_4H_9Cl	Isobutyl chloride	12	134	*D*	(35)
C_4H_9I	Isobutyl iodide	12	106	*D*	(35)
$C_4H_{10}S$	Ethyl sulfide	12	153	*D*	(35)
$C_4H_{10}O$	Isobutyl alcohol	12	157	*D*	(35)
$C_5H_{10}O_2$	*n*-Valeric acid	12	152	*D*	(35)
$C_5H_{10}O_2$	Isovaleric acid	12	147	*D*	(35)
$C_5H_{10}O_2$	Methyl butyrate	21	168	*C*	(30); *cf.* (35)
$C_5H_{10}O_2$	Propyl acetate	12	152	*D*	(35)
$C_5H_{11}Br$	Amyl bromide	12	118	*D*	(35); *cf.* (11)
$C_5H_{11}Cl$	Amyl chloride	12	136	*D*	(35)
$C_5H_{11}I$	Amyl iodide	12	104	*D*	(35)
$C_5H_{12}O$	*n*-Amyl alcohol	0	144	*C*	(9)
$C_5H_{12}O$	Dimethylethyl carbinol	0	124	*C*	(9)
C_6H_5Br	Bromobenzene	12	129	*D*	(35)
C_6H_5Cl	Chlorobenzene	12	143	*D*	(35)
$C_6H_5NO_2$	Nitrobenzene	12.5	158	*C*	(9)
C_6H_6	Benzene	20	170	*D*	(9, 11, 34, 35)*
C_6H_7N	Aniline	0	180	*C*	(9, 35); *cf.* (23)
$C_6H_{12}O_2$	Isocaproic acid	12	142	*D*	(35)
$C_6H_{12}O_2$	Ethyl butyrate	24	166	*C*	(30); *cf.* (35)
$C_6H_{12}O_2$	Methyl valerate	21	153	*C*	(30); *cf.* (11, 35)
C_6H_{14}	Hexane	4	142	*D*	(9, 13)
C_7H_9N	*p*-Toluidine (M. P., 45°C)	26	159 *s*	*C*	(20)
		38	138 *s*	*C*	(20)
		51	121 *l*	*C*	(20)
		64	113 *l*	*C*	(20)
$C_7H_{14}O_2$	Amyl acetate	12	143	*D*	(35); *cf.* (11)
$C_7H_{14}O_2$	Ethyl valerate	20	149	*C*	(30); *cf.* (11, 35)
C_7H_{16}	Heptane	4	141	*D*	(13)
C_8H_{10}	*o*-Xylene	21	156	*C*	(9); *cf.* (11)†
C_8H_{10}	*m*-Xylene	21	155	*C*	(9, 30); *cf.* (11)‡
$C_8H_{16}O_2$	Isobutyl butyrate	18	144	*C*	(30)
C_8H_{18}	Octane	4	157	*D*	(13)
$C_9H_{10}O_2$	Ethyl benzoate	32	160	*D*	(11)
$C_9H_{18}O_2$	Isobutyl valerate	21	137	*C*	(30)
$C_9H_{18}O_2$	Amyl butyrate	18	142	*C*	(30)
$C_{10}H_9N$	α-Naphthylamine (M. P., 50°C).	25	163 *s*	*C*	(20)
		41	146 *s*	*C*	(20)
		52	117 *l*	*C*	(20)
		62	117 *l*	*C*	(20)
$C_{10}H_{14}$	Cymene (*p*-methylisopropylbenzene)	12	132	*D*	(35); *cf.* (11)
$C_{10}H_{14}O$	Thymol (M. P., 13°C)	12	150 *s*	*D*	(2)
		13	131 *l*	*D*	(2)
$C_{10}H_{20}O_2$	Amyl valerate	21	138	*C*	(30)
$C_{11}H_{14}O_2$	Isobutyl benzoate	21	144	*C*	(30)
$C_{12}H_{16}O_2$	Amyl benzoate	23	141	*C*	(30); *cf.* (11)

III. Miscellaneous liquids

Formula	Substance	t	K_t	G	Lit.
$CaCl_2.6H_2O$§	Calcium chloride (M. P., 29°C).	24	627 *s*	*D*	(20)
		30	477 *l*		
		41	443 *l*		
$Na_2HPO_4.12H_2O$	Disodium phosphate (M. P., 35°C).	24	548 *s*	*C*	(20)
		32	514 *s*		
		39	502 *l*		
		49	477 *l*		
	Olive oil	4	175	*C*	(31, 33); *cf.* (7, 34)
	Castor oil	4	181	*C*	(31, 33)
	Poppy oil	4	169	*C*	(31, 33)
	Turpentine oil	12	127	*D*	(35); *cf.* 6, 10)
	Sweet almond oil	4	177	*D*	(32, 33)
	Sesame oil	4	175	*D*	(32, 33)
	Lemon peel oil	6	170	*D*	(7, 34)
	Peanut oil	4	168	*D*	(32, 33)
	Nutmeg oil	4	156	*D*	(32, 33)
	Copaiba oil	4	115	*D*	(32, 33)
	Canada balsam	4	115	*D*	(32, 33)
See also Vol. II, p. 151	Kerosene	*See* section I			
	Petroleum ether	*See* section I			
	Tar ("Holzteer")	79.5	135	*D*	(8)
	Vaseline	15	184	*C*	(20); *cf.* (24)

* In deriving K_t, the values for alcohol and toluene were considered.

† In deriving K_t, the value for *m*-xylene was considered.

‡ In deriving K_t, the value for toluene was considered.

§ Part of the apparent change on fusion may be due to a difference in the experimental errors pertaining to the measurement of K in solid and in liquid phase.

TABLE 11.—THERMAL CONDUCTIVITY (K) OF AQUEOUS SOLUTIONS

$K = K_w(1 - 10^{-5}\alpha p)$, K_w = conductivity of water at same temperature as applies to K, p grams of solute per 100 g of solution. In section II, computed conductivity is $K_c = K_w[1 - 10^{-5}(\alpha_1 p_1 + \alpha_2 p_2)]$, the α's being those given in section I. Data are relative to the following values for water: $K_{17.5} = 583$, $K_{20} = 587$, $K_{32} = 606.8$, unit is 10^{-5} watt/(cm °C). For exceptional solutions, *see* text and Table 8; G = grade of the data (*v.* p. 226).

Unit of $K = 10^{-5}$ watt/(cm °C).

I. One Solute

Solute	p	K_{32}	α	G	Lit.
HCl	12.5	528		*C*	(14)
	25	482			
	38	441			
H_2SO_4	30	521	464	*C*	(14, 35); *cf.* (6)
	60	438			
	90	354			
NH_3	26	452*	885	*B*	(20)
$C_{12}H_{22}O_{11}$†	25	506*	556	*B*	(20)
	52	422*			
	67	361*			
$Pb(NO_3)_2$	36	563	200	*C*	(14)
$ZnCl_2$	17.5	555	473	*C*	(14)
	35	508	473	*C*	(14)
$ZnSO_4$	16	578	275	*C*	(14, 34)
	32	555			
$CuSO_4$	18	577	272	*C*	(14, 34)
$MgCl_2$	11	576	488	*C*	(14)
	22	540			
$MgSO_4$	22	592	144	*C*	(14)
$CaCl_2$	15	579	309	*C*	(14)
	30	550			
$SrCl_2$	25	574	216	*C*	(14)
$Sr(NO_3)_2$	36	560	214	*C*	(14)
$BaCl_2$	21	584	176	*C*	(14)
NaCl	12.5	587	248	*C*	(14)
	25	570			
NaBr	20	564	302	*D*	(14)
	40	539			
Na_2SO_4	10	606	20	*C*	(14)
$NaNO_3$	22	571	235	*C*	(14)
	44	549			
Na_2CO_3	10	587	320	*C*	(14)
$NaC_2H_3O_2$‡	13	589	210	*D*	(14)
	23.1	578			
KOH	21	579	221	*C*	(14)
	42	550			
KCl	20	558	400	*C*	(14); *cf.* (18)
KBr	40	492	473	*D*	(14)
KI	20.	527	586	*D*	(14)
	40	472			
	60	395			
K_2SO_4	10	603	(70)	*C*	(14)
KNO_3	10	591	347	*C*	(14)
	20	559			
K_2CO_3	20	575	265	*C*	(14)

II. Two solutes (14); grade *C* (*v.* p. 226)

S_1	S_2	P_1	P_2	K_{32}	K_c
$Pb(NO_3)_2$	$Sr(NO_3)_2$	16	18	564	564
$CuSO_4$	$ZnSO_4$	8	12	569	573
$BaCl_2$	$CaCl_2$	7	12	575	577
NaCl	KCl	10	10	575	567
$NaNO_3$	KNO_3	20	10	563	557

III. Sea water (19); t = 17.5°C; grade *C* (*v.* p. 226)

p§	0	1	2	3	3.5	4
K	583	569	563	560	558	557

* K_{20}; for NH_3, d = 0.907 g/cm³. † Cane sugar. ‡ Sodium acetate. § p = grams of total salts per 100 g of sea water.

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(For a key to the periodicals see end of volume)

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GLASSES

See also Vol. II, p. 101 and errata sheet

Many of the best measurements of the conductivity of glasses have been merely incidental to the measurement of some other quantity; in such cases the exact composition of the glass has not been known and the kind of glass has been indicated only vaguely. The two observers (3, 13) who have especially studied the variation of K with the composition, have not used the most convincing methods for measuring K. Consequently, for values of K for glasses of known composition, we must rely on the work of a single observer, but his values receive considerable support from the observations of others who have less precisely defined the character of their glasses.

TABLE 12.—THERMAL CONDUCTIVITY (K) OF GLASSES OF TYPICAL COMPOSITIONS

Value of temperature coefficient is uncertain; it is probably > 0 (2, 6, 8, 9, 14).

OC = ordinary crown; BC = borosilicate crown; PPC = potash phosphate crown; BPC = baryta phosphate crown; HLS = heavy lead sand; OF = ordinary flint; HF = heavy flint.

Unit of $K = 10^{-5}$ watt/(cm °C); composition is by weight; grade *C* (*v.* p. 226).

Glass =	OC	BC	PPC	BPC	HLS	OF	HF
K_{45}	1000*	1130	825	760	670	855	720
Lit.	*	(3); *cf.* (2, 13)	(3); *cf.* (2, 13)	(3); *cf.* (2, 13)	(3); *cf.* (13)	(3, 7); *cf.* (2, 10, 13)	(3); *cf.* (2, 13)
P_2O_5			69.5	59.5			
As_2O_5			1.5	1.5			0.2
SiO_2	65.9	71.0			20.0	45.1	29.3
PbO					80.0	46.4	67.5
ZnO	2.0						
B_2O_3	2.5	14.0	3.0	3.0			
Al_2O_3		5.0	10.0	8.0			
MgO			4.0				
BaO	9.6			28.0			
Na_2O	5.0	10.0				0.5	
K_2O	15.0		12.0			8.0	3.0

* Grade *B*; limits of K_{45} = 980 to 1090; (3, 7); *cf.* (1, 9, 10, 12, 13, 14, 15, 16).

TABLE 13.—CONTRIBUTIVE THERMAL CONDUCTIVITIES (O) OF OXIDES IN GLASSES (3); *cf.* (13)

100 $K = O_1p_1 + O_2p_2 + \cdots O_np_n$, K = thermal conductivity of the glass, p_n = percentage by weight of oxide "n." [For other formulae, *see* (3, 13, 19).]

Example: Typical flint glass, 46.4% PbO, 45.1% SiO_2, 0.5% Na_2O, 8.0% K_2O; hence, 100 $K = 518 \times 46.4 + 1320 \times 45.1 + 294 \times 0.5 + 250 \times 8.0 = 85\,714$; $K = 857$ of the units of the table $= 857 \times 10^{-5}$ watt/(cm °C) $= 0.00857$ watt/(cm °C), which agrees well with critical value of Table 12.

Unit of $Op/100 = 10^{-5}$ watt/(cm °C) $= 2.389 \times 10^{-6}$ cal_{15}/(cm sec °C); $t = 45$°C.

Oxide	O	Oxide	O
P_2O_5	979	Al_2O_3	1082
As_2O_5	−5506	MgO	1552
Sb_2O_3	118	CaO	396
SiO_2	1320	BaO	526
PbO	518	Na_2O	294
ZnO	504	K_2O	250
B_2O_3	837		

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(For a key to the periodicals see end of volume)

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CRYSTALS

The isothermal surfaces surrounding a single, constant, point source of heat in the interior of a crystal of any type are coaxial ellipsoids of constant axial ratios, provided that the distance of the surface of the crystal from the source is great as compared with that of the isothermal surface. The thermal conductivities (A, B, C) along the several principal axes of these ellipsoids are proportional to the squares of the lengths of the semi-axes. These are the *principal* conductivities of the crystal, and the surface $\frac{x^2}{A} + \frac{y^2}{B} + \frac{z^2}{C} = 1$ is called the *thermal ellipsoid* of the material.

In the mathematically most general case there are certain rotation coefficients (67), but these have never been found in any actual crystal; gypsum, dolomite, apatite, and erythrite have been carefully examined for them (63, 64, 75); for these crystals they are certainly <0.05% of A. Hence the conductivity of a crystal is completely specified when the values of A, B, and C and the orientation of the thermal ellipsoid with reference to the crystalline axes are known, the conductivity along any[1] axis of the thermal ellipsoid being equal to the square of the length of that semi-axis.[2]

If $A = B = C$, the crystal is thermally isotropic; if $A = B \neq C$, it is uniaxial, the axis being in the direction of the C axis, if $A \neq B \neq C \neq A$, the thermal ellipsoid has two, and only two, central circular sections, and the crystal is thermally biaxial, the directions of the axes being the normals to these sections. If, of A, B, C, the one of intermediate value is less than the average of the other two, the crystal is said to be thermally +, in the contrary case it is —; in the former case the thermal ellipsoid is prolate, in the latter it is oblate.

By convention, the crystallographic axes of a crystal are denoted by the letters a, b, c, if three; if more than three, the interchangeable ones are denoted by a_1, a_2, . . . If there is a unique axis, that is taken as the c axis, except in the monoclinic system, where it is the b axis. When the crystal is in its normal position, c is vertical and the plane including c and the line of sight either includes the a axis or bisects the angle between two interchangeable a axes which are not mutually perpendicular. If $a \neq b \neq c \neq a$ and axes are mutually perpendicular (orthorhombic system) the axes are always so chosen that $a < b$, and usually so that $a < b < c$; a is called the brachy-axis, b the macro-axis. In the monoclinic system, b is the unique axis, c is the inclined axis which is parallel to the prismatic faces; the normal orientation of the crystal is such that a slopes downwards towards the observer. When there is uncertainty regarding which faces belong to the prism, a standard work on mineralogy should be consulted. The acute angle between c and a is denoted by β.

In the triclinic system c is the axis parallel to the prismatic faces (same uncertainty as before), usually $a < b$, and the orientation is such that the a axis slopes downward towards the observer. The angles between the positive directions of the axes are denoted by α, β, γ; $\alpha = \angle bc$, $\beta = \angle ca$, $\gamma = \angle ab$.

TABLE 14.—TYPE AND ORIENTATION OF THERMAL ELLIPSOID

Crystal system	Optical and thermal character	Thermal axes and orientation
Cubic	Isotropic	$A = B = C$
Trigonal, Tetragonal, Hexagonal	Uniaxial	$A = B \neq C$; C coincides with c. If $A = B < C$, crystal is +; if $A = B > C$, it is —.
Orthorhombic	Biaxial	$A \neq B \neq C \neq A$; A, B, C coincide with a, b, c.
Monoclinic	Biaxial	$A \neq B \neq C \neq A$; B coincides with b, C is that one of the other axes which is nearest to c; $\theta = \angle cC$ measured in direction of $\angle ca$.
Triclinic	Biaxial	$A \neq B \neq C \neq A$. For no crystal of this system have the thermal properties been completely investigated; for important work on $CuSO_4.5H_2O$, *see* (54).

Empirical Relations

Thermal.—There is some indication (*see* Table 16) that $K \propto T^{-1}$ if $T > 25$°K; in region 20°K to 25°K, K increases rapidly as T is reduced; diamond, however, shows little change until T is small, and then seems to decrease markedly. Until additional observations have been made we can do no more than assume that $K \propto T^{-1}$ holds approximately over ordinary ranges of T (24, 25, 28). On basis of same observations, it has been suggested that the smaller the number of atoms in the molecule of the crystal and the higher the melting point the greater is K. At their melting points, crystals of di- or tri-atomic molecules have approximately the same K (24).

Light.—In specimens of Se which are electrically sensitive to illumination, the thermal conductivity is increased by illumination, but much less than the electrical. The effect is difficult to detect. It is claimed that the effect increases with the wavelength of the light and decreases with the temperature (4, 45, 53, 62).

Electrical.—It is claimed that the higher the electrical, the lower the thermal conductivity, and that whatever increases the former reduces the latter. (For theoretical treatment, *see* (32).) On the other hand, for any single crystal it is maintained that as the orientation changes, the reciprocal of K varies linearly with the electrical volume resistivity (12).

[1] Not merely along a principal axis.

[2] For an experimental test by directly measuring conductivities other than principal ones, *see* (12).

Magnetic.—No uniform agreement between direction of maximum K and that of maximum μ; in calcite they coincide, in gypsum they do not (71); *cf.* (40, 41). For effect upon Bi, *see* note, Table 15 (section I).

Mechanical.—No data for effect of a pure strain; for effect of longitudinal compression of SiO_2, *see* note, Table 15 (section III); for negligible effect of torsion on Al, *see* note, Table 15 (section I).

Theoretical Relations

As the quantum theory has developed, several relations connecting K with certain atomic constants have been proposed (16, 17, 18, 23). Unfortunately, they can not be satisfactorily tested until more data are available. The type of formula is illustrated by the following expression for K, which is based upon considerations of the oscillation of the atoms in the space lattice (23):

$$K = 3\pi n k_0 \nu N a \left(\frac{h\nu}{k_0 T}\right)^2 e^{h\nu/k_0 T} / 2(e^{h\nu/k_0 T} - 1)^{3/2}$$

where n = a numerical factor depending on the character of the space lattice; k_0 = Boltzmann's gas constant (1.37×10^{-16} erg deg.$^{-1}$); ν = frequency of one of the lines in the "rest-strahlen" of Rubens; N = number of atoms per unit area perpendicular to the direction of flow of heat in the crystal; a = "centered distance" between two neighboring atoms in the direction of flow of heat; h = Planck's constant (6.554×10^{-27} erg sec); T = absolute temperature.

TABLE 15.—THERMAL CONDUCTIVITY OF CRYSTALS

For position of axes, *see* Table 14

A, B, C = principal conductivities, G = grade of accuracy (*see* p. 226); S = chemical symbol; t = temperature, °C; Hex, Mon, Rho, Tri, Tet denote the crystal systems hexagonal, monoclinic, orthorhombic, trigonal, tetragonal. The crystals are arranged in the table in accordance with the usual scheme *except* that all crystals containing Si have been grouped together under the Si position, and of these, all containing Al have been grouped under the SiAl position.

TABLE 15.—(*Continued*)

Unit of A, B, C = 1 watt/cm °C = 10^7cgs = 10^7erg/(cm sec °C) = 0.239 cal/(cm sec °C).

I. Elementary substances

S	System	t	A	A/C	G	Lit.
Al*	Cub	30	2.08		C	(14)
Bi	Tri	18	0.0924	1.39†	A	(33, 36, 44, 55); *cf.* (34, 35, 46)
C‡	Cub	0	2 *ca.*		D	(25)
C§	Tri	30	3.55	4.0	C, D	(35, 37, 38)
Cu	Cub	0	4.1		C	(60)
Sb	Tri			2.53	C	(34, 35)
Si	Cub	30	0.84		C	(37, 38)
Te	Hex			0.66	C	(35)

* A twist of 1.04° per cm produces no change >0.1 %.

† Magnetic field (H) = 4980 gauss, normal to c, increases A/C by 26.8 % (44).

‡ Diamond. § Graphite.

II. Compounds: cubic crystals, t = 0°C; $G = D$; $A = B = C = K$

Formula	K	Lit.
TlCl	0.00978	(28)
TlBr	0.00815	(28)
AgCl	0.0109	(28)
	0.0110*	(28)
AgBr	0.0103	(28)
CaF_2	0.103†	(24); *cf.* (56)
NaCl	0.0697‡	(24); *cf.* (70, 76)
$NaClO_3$	0.0111	(24)
KCl	0.0696§	(24, 25, 28)
KI	0.0502	(28)
$KCr(SO_4)_2.12H_2O$	0.00554	(24)

* Cerargyrite, hornsilver. † Fluorite. ‡ Halite, rock salt. § Sylvite.

III. Compounds: non-cubic crystals

Formula	Substance	System	Optically	A/C	B/C	θ	G	Lit.
H_2O*	Ice	Tri		<1		/		(3, 26); *cf.* (68)
$(NH_4)H_2PO_4$		Tet	−	1.28			C	(40)
$(NH_4)H_2AsO_4$		Tet	−	1.42			C	(40)
Sb_2S_3	Stibnite	Rho		0.47	0.29		C	(34); *cf.* (33, 61)
$Sb_2(Pb, Cu_2)_3S_6$	Bournonite	Rho		0.60	0.58		C	(34); *cf.* (61)
$Bi_2(Te, S)_3$†	Tetradymite	Tri		much > 1			D	(35)
$CO(NH_2)_2$	Urea	Tet	+	0.79			D	(40)
$C_4H_{10}O_4$	Erythritol	Tet		1.14			C	(41)
$C_{12}H_{22}O_{11}$	Cane sugar	‡		‡			D	(24)
SiO_2; *v. also* p. 106	Quartz§	Tri	+	0.575‡			B	(7, 24, 29, 33, 34, 35, 42, 47, 59, 61, 70); *cf.* (26, 56)
$ZrSiO_4$	Zircon	Tet	−	0.81			C	(34, 35)
$(Zn, Mn)_2SiO_4$†	Troostite	Tri	+	0.73			C	(34, 35)
$NiSiF_6.6H_2O$		Hex	+	0.86			C	(40)
(Al silicates)	Mica (biaxial)‖	Mon		5.84	6.30	v. s.	C	(34)
	Mica (*ca.* uniax)‖	Mon		5.29	6.00	v. s.	C	(34)
$Al_{12}Si_6F_{10}O_{25}$†	Topaz	Rho		0.94	0.95		D	(7)
$Al_3B_2Si_4H_{11}O_{21}$¶	Tourmaline	Tri	−	1.35			D	(34, 35); *cf.* (56, 61, 66, 69)
$Be_3Al_2Si_6O_{18}$	Emerald	Hex	−	0.81			C	(7, 34, 35, 61)
$(Mg, Fe)_6(Al, Fe)_{24}Si_{11}H_4O_{66}$¶	Staurolite	Rho		0.94	0.81		C	(34)
$(Mg, Fe)_5Al_2Si_3H_8O_{18}$†	Penninite	Tri**		1.35			C	(34, 35)
$Ca_4Al_6Si_6O_{25}$††	Scapolite	Tet	−	0.71			C	(34, 35)
$Ca_4(Al, Fe)_6Si_6O_{25}.H_2O$	Epidote	Mon		0.87	1.18	+14.5	C	(34)
$Ca_7R_4Al_2Si_6O_{24}$†	Vesuvianite	Tet	−	0.90			D	(7, 34, 35, 61)
$(Na_2, Ca)Al_2Si_4O_{12}.6H_2O$	Chabazite	Tri	+	0.97			D	(34); *cf.* (35)

III. Compounds: non-cubic crystals.—(*Continued*)

Formula	Substance	System	Optically	A/C	B/C	θ	G	Lit.
$Na_6K_2Al_8Si_9O_{34}$†	Nephelite	Hex		1.00			C	(35)
$KAlSi_3O_8$	Orthoclase	Mon		0.63	0.90	4‡‡	C	(34); *cf.* (56, 61)
Be_2SiO_4	Phenacite	Tri		0.92			C	(35)
$CaFe_5Si_4O_{16}.H_2O$¶	Ilvaite	Rho		1.33	1.01		C	(34)
$CaMg_3Si_4O_{12}$	Tremolite	Mon		0.36	0.57	5	C	(34)
$Ca(Mg, Fe)_3Si_4O_{12}$†	Hornblende	Mon		0.50	0.64	5	C	(34)
$Na_{13}(Fe, Ca)_6(Si, Zr)_2ClO_{18}$¶	Eudialyte	Tri	+	1.28			C	(34, 35)
$K_2Ca_8Si_{16}O_{41}.16H_2O$	Apophyllite	Tet	+	much > 1			D	(35); *cf.* (34)
TiO_2	Rutile	Tet	+	0.62			C	(7, 34, 35, 61)
TiO_2	Octahedrite	Tet	−	1.80			C	(35); *cf.* (34)
$SrSO_4$	Celestite	Rho		1.08	1.17		C	(34)
SnO_2	Cassiterite	Tet		0.7			D	(7, 34, 35); *cf.* (61)
Pb_2Cl_2O	Matlockite	Tet		much > 1			D	(35)
$Pb_2Cl_2CO_3$	Phosgenite	Tet		1.00			C	(35)
$PbSO_4$	Anglesite	Rho		1.25	1.30		D	(34)
$PbS_2O_6.4H_2O$		Hex	+	1.03			C	(40)
$Pb_{10}P_6Cl_2O_{24}$	Pyromorphite	Hex	−	0.95			C	(34, 35)
$PbMoO_4$	Wulfenite	Tet		1.00			C	(35)
$ZnCO_3$	Smithsonite	Tri		> 1			D	(35)
ZnO	Zincite	Tri		> 1			D	(35)
$Hd(NH_4)_4Cl_6$		Hex	+	< 1			D	(40)
Hg_2Cl_2	Calomel	Tet		0.59			C	(35, 61)
HgS	Cinnabarite	Tri		0.72			C	(35)
$Cu(NH_4)_2Cl_4.2H_2O$		Tet	−	0.86			C	(40)
Ag_8GeS_6	Argyrodite	Tri		1.23			C	(35)
$MnCO_3$	Rhodochrosite	Tri		> 1			D	(35)
Fe_2O_3	Hematite (red)	Tri		1.20‡			B	(7, 33, 34, 35); *cf.* (2, 61)
$FeTiO_3$	Ilmenite	Tri		1.23			D	(35)
Fe_7S_8	Pyrrhotite	Hex		1.14			D	(35)
$FeCO_3$	Siderite	Tri	−	1.12			C	(35); *cf.* (34)
$NiSO_4.6H_2O$		Tet	−	1.14			C	(40)
Al_2O_3	Corundum	Tri	+	0.85			C	(35); *cf.* (34, 61)
$MgCO_3$	Giobertite	Tri	−	1.10			C	(35); *cf.* (34)
$MgPt(CN)_4.7H_2O$		Tet	+	1.18			C	(40)
$Mg_2Fe(CO_3)_3$	Mesitite	Tri	−	1.12			C	(34, 35)
$CaSO_4$	Anhydrite	Rho		0.94	0.89		C	(34)
$CaSO_4.2H_2O$	Gypsum	Mon		0.64	0.42	+17	C	(34); *cf.* (11, 59, 61)
$CaS_2O_6.4H_2O$		Hex	−	0.92			C	(40)
$Ca_{10}P_6(F, Cl)_2O_{24}$	Apatite	Hex	−	0.85			D	(7, 33, 34); *cf.* (75)
$CaCO_3$	Calcite	Tri	−	0.84‡			A	(7, 34, 35, 42, 61, 70); *cf.* (56)
$CaCO_3$	Aragonite	Rho		> 1	< 1		D	(34); *cf.* (7)
$CaCu(C_2H_3O_2)_4.8H_2O$	Ca Cu acetate	Tet	+	0.83			C	(40)
$CaWO_4$	Scheelite	Tet		0.90			C	(35)
$CaCe_2F_2C_2O_6$¶	Parisite	Hex		1.25			C	(35)
$CaMg(CO_3)_2$	Dolomite	Tri	−	1.10			C	(7, 34, 35); *cf.* (75)
$BaSO_4$	Barite	Rho		1.13	1.05		C	(34); *cf.* (7, 56)
KH_2PO_4		Tet	−	1.45			C	(40)
KH_2AsO_4		Tet	−	1.29			C	(40)
K_4CdCl_6		Hex	+	0.87			C	(40)
$2KNa(NO_3)_2 + K_4Fe(CN)_6$		Hex	−	1.16			C	(40)

* Thermal conductivity of single crystals of ice has not been studied; indirect evidence (especially from orientation of crystals) indicates $A < C$, but can give no estimate of magnitude of A/C (3, 26); *cf.* (68).

† Composition variable. In vesuvianite, R_4 = Ca_2, $(AlOH)_2$, $(AlO_2H)_4$, or H_4. Hornblende contains Al and Na.

‡ For SiO_2, $A_{30} = 0.065$ (24, 25, 29, 42, 70); *cf.* (26, 56, 76), grade *B*; Fe_2O_3, $A_{30} = 0.146$ (35), grade *C*; Calcite, $C_{30} = 0.0418$ (42, 70); *cf.* (24, 56), grade *B*; $C_{12}H_{22}O_{11}$, not cubic, conductivity in direction not stated = 0.0058 at 0°C (24), grade *D*.

§ Ratio A/C is increased by pressure ∥ to *c*-axis and diminished by pressure ⊥ to *c*-axis; change in A/C (pressure not stated) amounted to about 10 % (61); *cf.* (34).

‖ These micas not clearly defined. Conductivity (undefined mica) in direction ⊥ plane of cleavage = 0.0057, t = 50°C (29); *cf.* (42).

¶Composition variable and doubtful. Parisite contains La and Dy.

** Perhaps strictly monoclinic. †† Contains Fe, Na, Cl. ‡‡ θ varies from +4° to −4°.

TABLE 16.—THERMAL CONDUCTIVITY (K) OF CRYSTALS: VARIATION WITH TEMPERATURE

It has been suggested that K varies as T^{-1}; compare the values of K_T/K_{273} with those of $273/T$, which are given in last line of the table. T = absolute temperature, °K. Grade = D (*v.* p. 226).

Formula	Substance	T =	373	196	195	88	83	Lit.
		Axis	K_T/K_{273}					
C	Diamond (1)	Cubic		1.06		0.85		(25)
	(2)			1.08		1.02		(25)
	(3)					0.89		(25)
$C_{12}H_{22}O_{11}$	Cane sugar	*			1.35			(24)
SiO_2	Quartz (1); *v. also* p. 106	*C*	0.66		1.44		3.60	(24)
		A, B	0.77		1.39		3.39	(24)
	(2)	*A, B*		1.35		2.89		(25)
	(3)	*A, B*		1.26		2.74		(25)
CaF_2	Fluorite	Cubic	0.77		1.46		3.77	(24)
$CaCO_3$	Calcite	*A, B*	0.83		1.34		3.68	(24)
NaCl	Halite	Cubic	0.69		1.50		3.82	(24)
$NaClO_3$	Na chlorate	Cubic			1.41			(24)
KCl	Sylvite (1)	Cubic	0.71		1.49		3.00	(24)
	(2)			1.43		2.61		(24)
		$273/T$ =	0.732	1.393	1.400	3.106	3.289	

* Direction is not stated; crystal is not cubic.

Substance* (25)		T =	23.1	23	22.3	22	21.9	21.6	21.4	21
C	Diamond (2)	Cubic								0.769
	(3)									0.483
SiO_2	Quartz (2)	*A, B*				33.0		35.2		39.4
	(3)	*A, B*		29.5	32.5		34.4		36.8	
KCl	Sylvite (2)	Cubic	7.02			7.46				8.40
		$273/T$ =	11.82	11.87	12.24	12.41	12.47	12.64	12.76	13.00

* Continuation of preceding portion of table, same specimens.

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FREE AND FORCED CONVECTION OF HEAT FROM BODIES OF SIMPLE SHAPE IN GASES AND LIQUIDS

CHESTER W. RICE

The data are here correlated on the film theory which assumes that the hot body is surrounded by a stationary film of fluid through which the heat is carried entirely by conduction. By this approximation the convection loss from bodies of simple geometric form, under widely different fluid conditions, can be computed by means of a few convenient equations. Such a correlation seems more needed at the present time than a plurality of complex equations giving a more exact representation of specific experimental conditions. When the effects of such specific conditions need to be considered, the original sources should be consulted.

For the method of correlation and summaries of the data used, *see* (**100, 101, 102**). The constants there given for the forced convection from cylinders, rough pipes, and large plane surfaces have here been revised to include the more recent data (**29, 34, 61**). The results obtained for a particular object under given flow conditions can be strictly applied only to a geometrically similar object under geometrically similar flow conditions. The importance of this limitation is well illustrated by the wide divergence found between the results of different investigators, which is mainly due to a lack of complete geometric similarity between the systems tested, rather than to errors of measurement.

The loss by *free convection* is the amount of heat, other than that lost by radiation, which leaves a hot body at rest in a large expanse of unstirred fluid. The loss by *forced convection* is the heat carried away by a stream of fluid flowing over the hot body. Only those cases of forced convection will be considered in which the velocity of the stream is large as compared with that of the natural free convection currents, so that the free convection loss may be neglected.

Heat transfers which are accompanied by a change of state (as between condensing vapors and evaporating liquids) are not considered.

Symbols

After certain definitions are symbols in [ ]; these indicate in each case the relation of the unit of the quantity defined to the fundamental units, as explained in the next section.

A	Area of the surface from which the convective loss is W_c; $[l^2]$.
a, b	Experimental exponents depending upon the geometrical shape of the hot body and the type of convection.
B	Effective thickness of the film of stationary fluid which surrounds the hot body; $[l]$.
C	A coefficient, *not* dimensionless, used in approximate equations for convection from large bodies in air.
c_p	Specific heat of the fluid at constant pressure; $[hm^{-1} \times \theta^{-1}]$.
D	A dimension of reference which serves to define the size of the hot body; $[l]$.
F_1	The dimensionless quantity $k/(\mu c_p)$.
F_2	The dimensionless quantity $\mu/\left(\rho\sqrt{agD^3\Delta(T)}\right)$
F_3	The dimensionless quantity $\mu/(\rho Dv)$
g	Acceleration of gravity; $[lt^{-2}]$.
h	The unit of quantity of heat.
K, K_g	Experimentally determined, dimensionless coefficients fixed by the geometrical properties of the system of bodies involved and by the type of convection. K applies to both liquids and gases, K_g to gases only.
k	Thermal conductivity of the fluid; $[hl^{-1}t^{-1}\theta^{-1}]$.
l	The unit of length.
m	The unit of mass.
P	Pressure of the gas.
R	Mechanical resistance to the flow of the fluid through the pipe; = retarding force per unit of area of the pipe; $[ml^{-1}t^{-2}]$.
T, T_1, T_2	Absolute temperature of the fluid, ambient fluid, and hot body, respectively; $[\theta]$.
T_a	Average film temperature, $T_a = (T_1 + T_2)/2$; $[\theta]$.
T_m	Geometric mean film temperature, $T_m = \sqrt{T_1 T_2}$; $[\theta]$.
ΔT	Excess in temperature of the hot surface above that of ambient fluid, $\Delta T = T_2 - T_1$; $[\theta]$.
t	Unit of time.
v	Mean velocity of fluid relative to the hot body; $[lt^{-1}]$.
W_c	Total convective loss from area A per unit of time; $[ht^{-1}]$.
α	Fractional change in density of the fluid per unit change in temperature; $[\theta^{-1}]$. (For a perfect gas, $\alpha = 1/273$ per °C.)
β, γ, δ, ϵ	Exponents used in approximate equation for convection from large bodies in air.
θ	The unit of temperature difference.
μ	Viscosity of the fluid; $[ml^{-1}t^{-1}]$.
ρ	Density of the fluid; $[ml^{-3}]$.

$\Delta\varphi \equiv \int_{T_1}^{T_2} k dT = k_e \Delta T$, where k_e may be called the effective average conductivity of the fluid between the temperatures T_1 and T_2.

Units

For any of the equations in this report the units of temperature $[\theta]$, of heat $[h]$, of length $[l]$, of mass $[m]$ and of time $[t]$ may be chosen as convenient, unless the contrary is definitely stated or definite units are named, but a choice once made should be consistently adhered to for all the quantities involved in the equation under consideration. The unit of each of the other quantities is built up of those named, as indicated in the list of symbols, each symbol in [ ] being replaced by the name of its chosen unit, as in the following examples. Under these conditions the numerical values of dimensionless quantities, such as F_1, F_2, F_3, K, and K_g, are independent of the particular choice of units for θ, h, l, m and t. For example, if the units chosen are θ = 1°C, h = 1 joule, l = 1 cm, m = 1 g, and t = 1 sec, then the unit of $k[hl^{-1}t^{-1}\theta^{-1}]$, is 1 joule cm^{-1} sec^{-1} $(°C)^{-1}$ = 1 watt cm^{-1} $(°C)^{-1}$, that of c_p $[hm^{-1}\theta^{-1}]$, is 1 joule g^{-1} $(°C)^{-1}$, of $R[ml^{-1}t^{-2}]$, is 1 g cm^{-1} sec^{-2} = 1 dyne cm^{-2}, etc.; if the chosen units are θ = 1°F, h = 1 BTU, l = 1 cm, m = 1 lb., and t = 1 sec, the unit of k is 1 BTU cm^{-1} sec^{-1} $(°F)^{-1}$, of c_p is 1 BTU lb^{-1} $(°F)^{-1}$, of R is 1 lb. cm^{-1} sec^{-2}, etc. The numerical values of F_1, F_2, F_3, K and K_g are the same in each case. In all cases in which nothing is said regarding units, the following equations are, as they stand, equally valid whatever the choice of units for θ, h, m, l and t, provided the choice is consistently adhered to. In certain cases a departure from consistency is allowable, but no such departure should be made without due consideration.

General Relations

For both free and forced convection $W_c = \dfrac{2A\Delta\varphi}{D\log_e(1+2B/D)}$ for cylinders and tubes, and $W_c = \dfrac{A}{B}\left(1 + \dfrac{2B}{D}\right)\Delta\varphi$ for spheres; D is the diameter of cylinder, tube, or sphere. If D is great as com-

pared with the film thickness B (say, $D > 10B$), each expression reduces to $W_c = (A\Delta\varphi)/B$, which also applies to flat surfaces. The values of $\Delta\varphi$ for Air, H_2, N_2, CO_2 and Hg vapor, have been given by Langmuir (54). For moderate values of ΔT (say, for $\Delta T < 100°C$) and when values of $\Delta\varphi$ are not available, the approximation $\Delta\varphi = k\Delta T$ is used.

For free convection, $B = KDF_1^aF_2^b$; for forced convection, $B = KDF_1^aF_3^b$. In computing the values of F_1, F_2 and F_3 the temperature of the fluid is to be taken as $T_a = (T_1 + T_2)/2$ for all cases of free convection and for forced convection when $(T_2 - T_1)$ is not great (say, for $\Delta T < 100°C$), and as $T_m = \sqrt{T_1T_2}$ for forced convection when $(T_2 - T_1)$ is great. For ideal gases and for air $F_1 = 1.35$, and if $K_v = 1.35^aK$, the expressions for B become $B = K_vDF_2^b$ for free, and $B = K_vDF_3^b$ for forced convection.

For forced convection in pipes, the film theory of convection suggests that $W_c = ARk(\Delta T)/v\mu F_1^a = ARF_1^{1-a}c_p(\Delta T)/v$ which, when R is replaced by its empirical expression for smooth pipes (56) and a is taken as 0.5 (*see* Table 2), becomes $W_c = 0.0009F_1^{1/2} \times A\rho vc_p(\Delta T)[1 + 84.8F_3^{0.35}]$. This should be applicable to gases and liquids at all values of v above the critical velocity at which the flow becomes turbulent. For ideal gases it reduces to $W_c = 0.00105\,A\rho vc_p(\Delta T)[1 + 84.8F_3^{0.35}]$.

Special Relations for Air.—The equations in this section assume that the unit of P is 1 atm. and that the units of the other quantities are built up from $\theta = 1°C$, $h = 1$ joule, $l = 1$ cm, $m = 1$ g, and $t = 1$ sec, in the manner indicated on p. 234, T and T_a being absolute Kelvin temperatures. In general they are not valid for other units. They are obtained by substituting in the equations already given the following values, applicable to air: $\mu = 2.48 \times (10)^{-6}T^{0.754}$g cm^{-1} sec^{-1}, $k = 3.45(10)^{-6}T^{0.754}$ watt cm^{-1}(°C)$^{-1}$, $\rho/\mu = 0.142(10)^6P/T^{1.754}$ sec cm^{-2}, and $c_p = 1.03$ joule g^{-1}(°C)$^{-1}$. $W_c = (10)^{-4}CAP^\beta(\Delta T)^\gamma/(D^\delta T_a^\epsilon)$ for free, and $W_c = (10)^{-4}CA \times (Pv)^\beta(\Delta T)/(D^\delta T_a^\epsilon)$ for forced convection; the factor $(10)^{-4}$ has been separated from the C for convenience in tabulation. The value of C depends upon the properties of air, the form and orientation of the body, the type of convection, and the units in which the quantities are measured. For forced convection in smooth pipes at values of v above the critical velocity at which the flow becomes turbulent, $W_c = [0.000375APv(\Delta T)/T_a] \times [1 + 1.35T_a^{0.614}/(PDv)^{0.35}]$.

Table 1.—Free Convection

If D/B is great, $W_c = A(\Delta\varphi)/B$; if ΔT is not great, $\Delta\varphi = k\Delta T$. In all cases $B = KDF_1^aF_2^b$; for approximately ideal gases, such as air, $B = K_vDF_2^b$. For these equations the units of θ, h, l, m and t, may be chosen as convenient, *see* p. 234. For air only, $W_c = (10)^{-4}\ CAP^\beta(\Delta T)^\gamma/(D^\delta T_a^\epsilon)$, if D/B is great and ΔT is not great; for this equation the units must be as follows: Unit of $W_c = 1$ watt, of $A = 1$ cm^2, of $P = 1$ atm., of $\Delta T = 1°C$, of $D = 1$ cm and of $T_a = 1°K$. 1 watt = 1 joule/sec; 1 joule = 10^7 erg = 0.2389 gram calorie (15°C) = 0.0009482 BTU (60°F). In the second section of the table, numbers in column headed % are the values of $100[W_{c(observed)} - W_{c(calculated)}]/W_{c(calculated)}$. The serial number N serves to indicate corresponding items in the two sections of the table.

N	Type of surface	D	Gases and liquids			Gases*	
			K	a	b	K_v	b
1	Cylinder, horizontal†	Diameter	2.6	0.25	0.54		
2	Cylinder, horizontal‡	Diameter	2.1	0.25	0.50	2.27	0.50
3	Cylinder, vertical§	§				8.7	0.66
4	Sphere‖	Diameter				2.0	0.50
5	Ribbon, horizontal, plane vertical¶	Breadth**				1.46	0.50

N	Type of surface	D	Air C	Air β	Air γ	Air δ	Air ϵ
1	Cylinder, horizontal†	Diameter					
2	Cylinder, horizontal‡	Diameter	7.9	0.50	1.25	0.25	0.123
3	Cylinder, vertical§	§	17	0.66	1.33	0	0.415
4	Sphere‖	Diameter	8.8	0.50	1.25	0.25	0.123
5	Ribbon, horizontal, plane vertical¶	Breadth**	12	0.50	1.25	0.25	0.123
6	Large plane, vertical††	††	2.0	0.50	1.25	0	0
7	Large plane, horizontal, face up††	††	2.6	0.50	1.25	0	0
8	Large plane, horizontal, face down§§§	††	1.3	0.50	1.25	0	0
9	Transfer between vertical planes‖‖‖	††	1.2	0	1.25	0	0

N	Type of surface	Fluid	P	%	Lit.
1, 2	Small wires	Air	0.5 to 2.25	− 5	(46)
	Small wires, large ΔT	Air, H_2, Hg vapor	1	− 5	(51)
	Small wires	Air, H_2, CO_2	1 to 150	±10	(86, 87)
	Small wires in liquids‡‡	C_6H_7N, CCl_4, $C_3H_8O_3$, C_7H_8		± 5	(26)
	Wire	Air	1	+10	(2)
	Large cylinders	Air	0.1 to 1	− 5	(100)
	See also (4, 5, 6, 15, 39, 54, 65, 70, 83, 88, 124)				
3	Large vertical cylinder§§	Air	1	± 5	(35)
	See also (51, 72)				
4	Spheres, D = 15, 20, 30 cm	Air	1	−10	(83)
	Sphere, D = 4 cm	Air	1	+13	(64)
	See also (4, 22, 32); data of (22) are very discordant; probably the thick coat of lampblack on the small sphere introduced an error.				
6	Disks, D = diameter = 19.1 cm‖‖	Air	1	−30	(53)
	Vertical plane¶¶	Air	1	+15	(35)
	Vertical plate***	Air	1	−10	(31)
	Vertical plate†††	Air	1	+10	(67)
	Vertical cylinders‡‡‡	Air	1	+ 8	(35)
	See also (4, 66)				

* Approximately ideal gases, such as air.

† Good data covering wide experimental range, gases and liquids; $0.0003 \leq F_2 \leq 50$.

‡ This is a convenient approximation.

§ Only observations available are for one cylinder (D = 17.43 cm) in air. As b is essentially ⅔, DF_2^b is essentially independent of D, and for computational purposes D may be given any finite value, conveniently unity.

‖ Data are very scanty and for air only.

¶ Rough approximation based on an average of all available data for vertical plane surfaces.

** Vertical breadth.

†† Rough approximation for surfaces at least 100 cm by 100 cm and for T_a equivalent to 75°C ± 50°C. For the sake of obtaining an expression which is convenient for calculation, dimensional requirements have been violated. As $\delta = 0$, D does not enter into the expression for W_c.

‡‡ C_6H_7N = aniline, $C_3H_8O_3$ = glycerol, C_7H_8 = toluene.

§§ D = 17.43 cm.; height of cylinder = 28.8 cm.

‖‖ Polished silver and calorized copper; vertical, face up, and face down.

¶¶ Polished aluminum, 127 cm by 127 cm.

*** Lampblack covered steel plate 24.4 cm high and 38.1 cm long.

††† Lampblack covered steel plate 80 cm high and 33.2 cm long.

‡‡‡ Lampblack covered; D = 17.43 cm, heights = 4.65, 8.0, 15.2 and 28.8 cm (*cf.* N = 3).

§§§ No downward projecting edge. Derived from ratio to vertical surfaces (53).

‖‖‖ Transfer between two planes x cm apart ($1.27 \leq x \leq 5.08$) in air at atmospheric pressure. For this range in x, W_c is independent of x and of division into cells by horizontal partitions. Based entirely on (35).

Table 2.—Forced Convection

If D/B is great, $W_c = A(\Delta\varphi)/B$, and if ΔT is not great, $\Delta\varphi = k\Delta T$. In all cases $B = KDF_1^aF_3^b$; for approximately ideal gases, such as air, $B = K_vDF_3^b$. For these equations the units of θ, h, l, m and t may be chosen as convenient. For air only, $W_c = (10)^{-4}\ CA(Pv)^\beta(\Delta T)/(D^\delta T_a^\epsilon)$, if D/B is great and ΔT is not great; for this equation the units must be as follows: Unit of $W_c = 1$ watt, of $A = 1$ cm^2, of $P = 1$ atm., of $v = 1$ cm sec^{-1}, of $\Delta T = 1°C$, of $D = 1$ cm and of $T_a = 1°K$. 1 watt = 1 joule/sec; 1 joule = 10^7 erg = 0.2389 g cal (15°C) = 0.0009842 BTU (60°F). In the second section of the table, numbers in column headed %

TABLE 2.—(*Continued*)

are the values of $100[W_{c(\text{observed})} - W_{c(\text{calculated})}]/W_{c(\text{calculated})}$. The serial number N serves to indicate corresponding items in the two sections of the table.

N	Type of surface	D	Gases and liquids			Gases*	
			K	a	b	K_g	b
1	Cylinder, horizontal, flow transverse†	Diameter	2.8	0.4	0.57	3.15	0.57
2	Cylinder, horizontal, flow transverse‡	Diameter					
3	Pipe, smooth; approximate§	Diameter	60	0.50	0.83	70	0.83
4	Pipe, rough; approximate‖	¶	220	0.50	1.0	255	1.0
5	Large plane, smooth; approximate**	¶	220	0.50	1.0	255	1.0
6	Large plane, rough; approximate**	¶	150	0.50	1.0	175	1.0
7	Large plane, very rough¶¶; approximate**	¶	110	0.50	1.0	128	1.0

N	Type of surface	D	Air			
			C	β	δ	ϵ
1	Cylinder, horizontal, flow transverse†	Diameter	9.7	0.57	0.43	0.246
2	Cylinder, horizontal, flow transverse‡	Diameter	8.5	0.50	0.50	0.123
3	Pipe, smooth; approximate§	Diameter	9.7	0.83	0.17	0.71
4	Pipe, rough; approximate‖	¶	19	1.0	0	1.0
5	Large plane, smooth; approximate**	¶	19	1.0	0	1.0
6	Large plane, rough; approximate**	¶	28	1.0	0	1.0
7	Large plane, very rough¶¶; approximate*	¶	38	1.0	0	1.0

N	Type of surface	Fluid	P	%	Lit.
1, 2	Small wires††	Air	1	− 5	(47)
	Small wires	Air	1	− 5	(46, 52)
	Small wires	Air	0.5 to 4	+ 5	(45)
	Small wires	Water; oils		±10	(29)
	Large cylinders	Air	1	−15	(40)
	Large cylinders	Air	1	±10	(34)
	See also (6, 41, 69, 118, 119, 120, 124, 125)				
3	Brass tubes	Water		−10	(112)
	Brass tubes	Air	1	+20	(81)
	Copper tubes	Water		+10	(114, 115); *cf.* (112)
	Copper tubes	Water		−15	(113)
	Copper tubes	Air	1	+10	(42)
	Steel tube	Water		±30	(21)
	Tubes	Water; oils		−10	(62)
	Tubes (summary)	Water		−10	(63)
	Brass tube	Gases	1.5 to 16	± 5	(73, 74)
	See also (7, 33, 36, 37, 43, 44, 58, 60, 68, 71, 94, 103, 104, 109, 117, 121, 123)				
4	Rough tube‡‡	Water		±10	(114, 115); *cf.* (112)
	Tubes and ducts§§	Air	1	±10	(61)
	See also (60, 100)				

* Approximately ideal gases, such as air.

† Good data covering wide experimental range in gases and liquids; $0.00002 \leq F_3 \leq 3.0$.

‡ Convenient approximation for large cylinders.

§ For very turbulent flow. More accurate results for gases and liquids are given by the equation $W_c = 0.0009F_1^{0.5}A\rho v c_p(\Delta T)[1 + 84.8F_3^{0.35}]$, which for ideal gases becomes $W_c = 0.00105A\rho v c_p(\Delta T)[1 + 84.8F_3^{0.35}]$; choice of units as for the equations involving K and K_g. For air only, $W_c = [0.000375AP v(\Delta T)/T_a][1 + 1.35T_a^{0.614}/(PDv)^{0.25}]$; units as for the equation in C. All these equations assume that the pipe is smooth.

‖ Roughness of medium sand; approximation suitable for engineering work.

¶ In this case $b = 1$, hence, as $F_3 = \mu/\rho\, Dv$, DF_3^b is independent of D, and for the computations for the equations in K and K_g, D may be given any finite value, most conveniently unity. Also, as $\delta = 0$, the value of D is not involved in these special equations for air.

** Based on average results; convenient approximation for engineering work when flow is parallel to surface and the velocity is high.

†† Data for $v < 100$ cm/sec have not been used.

‡‡ Crossed threads approximately 0.025 cm deep.

§§ Ducts were built up of laminated iron.

¶¶ Roughness of coarse sand.

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RADIOMETRY (HEAT AND LIGHT)

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RADIATION CONSTANTS

W. W. Coblentz

For a perfect (black-body) radiator, the total hemispherical radiation (over all wave-lengths) at the absolute temperature T is $J = \sigma T^4$; σ is known as the Stefan-Boltzmann constant of total radiation. The hemispherical radiation included in the spectral region $(\lambda - \frac{1}{2}d\lambda)$ to $(\lambda + \frac{1}{2}d\lambda)$ is $J_\lambda d\lambda = C_1\lambda^{-5}[e^{C_2/\lambda T} - 1]^{-1}d\lambda$; C_1 and C_2 are known, respectively, as the first and the second radiation constants, and J_λ as the monochromatic intensity of the hemispherical radiation. At each temperature T, there is a wave-length λ_m at which J_λ is a maximum; $w(= \lambda_m T)$ is independent of T, and is known as Wien's displacement constant; $C_2 = \alpha w$, where $\alpha = 4.9651$ is a pure numeric.

Stefan-Boltzmann Constant (σ) of Total Radiation

$J = \sigma T^4$; σ_o = observed, or reported value; σ_p = probable value after correcting for reflection, etc. Unit of $\sigma = 10^{-5}$ erg cm^{-2} sec^{-1} $(°K)^{-4}$ = 6.451×10^{-12} watt $in.^{-2}$ $(°K)^{-4}$.

Observer	Year	σ_o	σ_p	Method
Kurlbaum [12]	1898	5.45	(?)	Bolometer
Féry [6]	1909	6.3	(?)	Thermometer
Bauer and Moulin [2]	1909	5.30	5.7	Thermopile
Bauer and Moulin [2]	1910	5.7	5.7	Pyrheliometer
Todd [19]	1909	5.48	5.48	Gas-conduction
Valentiner [20]	1910	5.58	5.68 to 5.75	Bolometer
Féry and Drecq [7]	1911	6.51	(?)	Thermometer
Féry and Drecq [7]	1912	6.2	5.68	Pyrometer*
Féry and Drecq [7]	1912	5.57		
Shakespear [18]	1912	5.67	5.67	Emissivity†
Gerlach [8]	1916	5.85		Pyrheliometer‡
Gerlach [8]	1920	5.80	5.80	
Puccianti [16]	1912	5.96	5.96	Bolometer
Puccianti [16]		6.15	(?)	Thermometer
Westphal [27]	1916	5.67	5.67	Emissivity†
Keene [11]	1913	5.89	5.89	Thermometer
Coblentz [3, 4]	1915	5.72	5.73	Pyrheliometer‡
Kahanowicz [10]	1917	5.61	5.69 to 5.73	Pyrheliometer‡
Wachsmuth and Vierheller [21]	1921	5.73	5.73	Emissivity§
Hoffman [9]	1923	5.76	5.76	Westphal's‖
Kussmann [13]	1924	5.79	5.79	Coblentz's
Mean value			5.72 to 5.74	

* Calibrated pyrometer.
† Ratio of radiance from metal to that from "black-body."
‡ Modified Ångström pyrheliometer.
§ From blackened sphere.
‖ Modification of Westphal's method.

Wien's Displacement Constant (w) and the Constant (C_2) of Spectral Radiation

$J_\lambda = C_1\lambda^{-5}[e^{C_2/\lambda T} - 1]^{-1}$; $w = \lambda_m T$; w_o = observed (recorded) value; w_c = value after correction for reflection, etc.; $C_2' = 4.9651w$ and values derived from isochromatics; C_2 = probable value after corrections have been applied. *Note:* $\left\{\begin{matrix}14\,200\\14\,600\end{matrix}\right\}$ denote 14 200 to 14 600. Unit of w and of $C_2 = 10^{-4}$ cm, °K = 1μ, °K.

Observer	Year	w_o	w_c	C_2'	C_2	Remarks
Paschen [15]	1899	2 891	2 891		14 360	Fluorite prism
		2 907	2 907*			T is questioned
	1900	2 921	2 894			
Lummer and Pringsheim [14]	1900	2 879	2 879	14 290		Fluorite prism*†
		2 876	2 876			
		2 940	2 882	14 310	14 300	
Warburg, *et al.* [21-26]	1911			14 200 14 600		Fluorite prism
	1912			14 300 14 400		Fluorite prism
	1912			14 360		Quartz prism

WIEN'S DISPLACEMENT CONSTANT (w) AND THE CONSTANT (C_2) OF SPECTRAL RADIATION.—(*Continued*)

Observer *	Year	w_o	w_ϵ	C_2'	C_2	Remarks
Warburg, *et al.*—	1913	2 894		14 370		Quartz prism
(*Cont'd*).....	1915			14 250‡		
	1915			14 300 14 400	14 300	Quartz prism†
Coblentz (4, 5)..	1913	2 911		14 456		Fluorite prism
	1916	2 894		14 369		Revised§
	1920			14 311 14 326	14 318	Zero correction‖
Rubens and Michel (17)	1921			14 300	14 300¶	
Average value...			2 885		14 320	

* Temperature scale is questioned.
† Calibration of prism is questioned.
‡ Temperature deduced from Stefan-Boltzmann law.
§ Calibration of prism revised and preceding data recomputed.
‖ Correction for zero setting of bolometer.
¶ Adopted in testing Planck's equation.

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RADIATION FROM A PERFECT (BLACK-BODY) RADIATOR

F. E. FOWLE

The following tables, giving the hemispherical radiation (J) and the monochromatic intensity (J_λ) of the hemispherical radiation of a perfect radiator, have been computed from the values of C_1 ($=3.703 \times 10^{-5}$ erg cm^{-2} sec^{-1}), C_2($=1.433$ cm, °K), and σ($=5.709 \times 10^{-5}$ erg cm^{-2} sec^{-1} (°K)$^{-4}$) which have been accepted for the purposes of International Critical Tables. A third table indicates how the values of J_λ are affected by changes in the value of C_2.

A line over a number indicates that it is negative. Thus (Table 1) at -270°C, $J = 5.272 \times 10^{-3} = 0.005272$.

The radiator receives radiation from surrounding bodies. If its temperature is T and if it is entirely surrounded by other perfect radiators, all at temperature T', its resultant loss of energy by radiation (net hemispherical radiation) will be $J_T - J_{T'}$, per unit of area. If $T = 1273.1$°K and $T' = 273.1$°K, the net hemispherical radiation will be $(1500 - 3.2) \times 10^5 = 1497 \times 10^5$ erg cm^{-2} sec^{-1}. (*See* Table 1.) Similarly for J_λ.

TABLE 1.—TOTAL HEMISPHERICAL RADIATION (J) OF A PERFECT (BLACK-BODY) RADIATOR

$J = \sigma T^4 = A \times 10^n$. $\sigma = 5.709 \times 10^{-5}$ erg cm^{-2} sec^{-1} (°K)$^{-4}$. T = absolute temperature, °K; t = centigrade temperature. Unit of $J = 1$ erg cm^{-2} sec^{-1} $= 2.389 \times 10^{-8}$ cal$_{15}$ cm^{-2} sec^{-1} $= 6.112 \times 10^{-10}$ BTU$_{60}$ in.$^{-2}$ sec^{-1}.

t	T	A	n	t	T	A	n
−273	0.1	5.71	$\bar{9}$	−180	93.1	4.289	3
−270	3.1	5.272	$\bar{3}$	−170	103.1	6.451	3
−260	13.1	1.681	0	−160	113.1	9.342	3
−250	23.1	1.626	1	−150	123.1	1.311	4
−240	33.1	6.852	1	−140	133.1	1.792	4
−230	43.1	1.970	2	−130	143.1	2.394	4
−220	53.1	4.539	2	−120	153.1	3.137	4
−210	63.1	9.050	2	−110	163.1	4.040	4
−200	73.1	1.630	3	−100	173.1	5.126	4
−190	83.1	2.722	3	− 90	183.1	6.417	4
− 80	193.1	7.937	4	46	319.1	5.918	5
− 70	203.1	9.714	4	48	321.1	6.070	5
− 60	213.1	1.177	5	50	323.1	6.221	5
− 50	223.1	1.414	5	52	325.1	6.377	5
− 40	233.1	1.686	5	54	327.1	6.535	5
− 30	243.1	1.994	5	56	329.1	6.697	5
− 20	253.1	2.343	5	58	331.1	6.862	5
− 10	263.1	2.735	5	60	333.1	7.029	5
− 8	265.1	2.820	5	70	343.1	7.912	5
− 6	267.1	2.906	5	80	353.1	8.875	5
− 4	269.1	2.993	5	90	363.1	9.923	5
− 2	271.1	3.084	5	100	373.1	1.106	6
0	273.1	3.176	5	200	473.1	2.860	6
+ 2	275.1	3.270	5	300	573.1	6.158	6
4	277.1	3.366	5	400	673.1	1.172	7
6	279.1	3.464	5	500	773.1	2.039	7
8	281.1	3.565	5	600	873.1	3.318	7
10	283.1	3.668	5	700	973.1	5.119	7
12	285.1	3.772	5	800	1073.1	7.570	7
14	287.1	3.879	5	900	1173.1	1.081	8
16	289.1	3.988	5	1 000	1273.1	1.500	8
18	291.1	4.100	5	1 500	1773.1	5.643	8
20	293.1	4.213	5	2 000	2273.1	1.524	9
22	295.1	4.330	5	3 000	3273.1	6.552	9
24	297.1	4.448	5	4 000	4273.1	1.903	10
26	299.1	4.569	5	5 000	5273.1	4.414	10
28	301.1	4.692	5	6 000	6273.1	8.841	10
30	303.1	4.818	5	7 000	7273.1	1.598	11
32	305.1	4.947	5	8 000	8273.1	2.674	11
34	307.1	5.078	5	9 000	9273.1	4.221	11
36	309.1	5.211	5	10 000	10273.1	6.358	11
38	311.1	5.348	5	15 000	15273.1	3.106	12
40	313.1	5.486	5	20 000	20273.1	9.644	12
42	315.1	5.628	5	25 000	25273.1	2.329	13
44	317.1	5.772	5				

TABLE 2.—MONOCHROMATIC INTENSITY (J_λ) OF HEMISPHERICAL RADIATION OF PERFECT (BLACK-BODY) RADIATOR

$J_\lambda = C_1 \lambda^{-5}[e^{C_2/\lambda T} - 1]^{-1}$, T = absolute temperature, λ = wave-length of the radiation. Total hemispherical radiation in range λ_1 to λ_2 is $\int_1^{\lambda_2} J_\lambda d\lambda$. If $C_1 = 3.703 \times 10^{-5}$ erg cm^2 sec^{-1}, $C_2 = 1.433$ cm, °K and unit of $d\lambda = 1$ cm, then $J_\lambda = A \times 10^n$ erg cm^{-3} sec^{-1}, where A and n have the values tabulated below. 1 erg cm^{-3} sec^{-1} $= 2.389 \times 10^{-8}$ cal$_{15}$ cm^{-3} sec^{-1} $= 6.118 \times 10^{-10}$ BTU$_{60}$ in.$^{-2}$ sec^{-1} $\times$ $(d\lambda)_{cm}^{-1}$, where $(d\lambda)_{cm}$ indicates that unit of $d\lambda = 1$ cm. For each T the maximum value of J_λ is printed in bold face. In column λ, unit of $\lambda = 1\mu = 10^4$Å $= 10^{-4}$ cm; T = absolute temperature, °K.

T	25		50		75		100		125		150		175		200		225		250	
λ	A	n	A	n	A	n	A	n	A	n	A	n	A	n	A	n	A	n	A	n
1.0	3.7	$\bar{2}34$	1.3	$\bar{1}09$	4.1	$\bar{6}8$	2.2	$\bar{4}7$	6.0	$\bar{3}5$	1.2	$\bar{2}6$	1.0	$\bar{2}0$	2.8	$\bar{1}6$	8.1	$\bar{1}3$	4.7	$\bar{1}0$
1.5	4.9	$\bar{1}52$	4.9	$\bar{6}9$	2.3	$\bar{4}1$	1.6	$\bar{2}7$	3.1	$\bar{1}9$	1.1	$\bar{1}3$	1.0	$\bar{9}$	8.8	$\bar{7}$	1.8	$\bar{4}$	1.23	$\bar{2}$
2.0	3.9	$\bar{1}11$	6.8	$\bar{4}9$	3.8	$\bar{2}8$	8.8	$\bar{1}8$	1.5	$\bar{1}1$	2.1	$\bar{7}$	1.9	$\bar{4}$	3.2	$\bar{2}$	1.72	0	4.2	1
2.5	9.9	$\bar{8}7$	6.4	$\bar{3}7$	2.4	$\bar{2}0$	4.8	$\bar{1}2$	4.6	$\bar{7}$	9.6	$\bar{4}$	2.27	$\bar{1}$	1.36	1	3.26	2	4.2	3
3.0	1.6	$\bar{7}0$	5.0	$\bar{2}9$	3.3	$\bar{1}5$	2.7	$\bar{8}$	3.8	$\bar{4}$	2.26	$\bar{1}$	2.12	1	6.5	2	9.2	3	7.7	4
3.5	5.1	$\bar{5}9$	1.9	$\bar{2}3$	1.4	$\bar{1}1$	1.17	$\bar{5}$	4.2	$\bar{2}$	9.8	0	4.8	2	9.1	3	8.8	4	5.4	5
4	2.1	$\bar{5}0$	2.8	$\bar{1}9$	6.5	$\bar{9}$	1.00	$\bar{3}$	1.29	0	1.54	2	4.6	3	6.0	4	4.40	5	2.16	6
5	1.9	$\bar{3}8$	1.5	$\bar{1}3$	3.0	$\bar{5}$	4.2	$\bar{1}$	1.30	2	5.9	3	9.1	4	7.1	5	3.47	6	1.25	7
6	1.6	$\bar{3}0$	8.6	$\bar{1}0$	7.1	$\bar{3}$	2.03	1	2.40	3	5.8	4	5.62	5	3.11	6	1.18	7	3.38	7
7	6.1	$\bar{2}5$	3.7	$\bar{7}$	3.1	$\bar{1}$	2.84	2	1.70	4	2.60	5	1.83	6	7.87	6	2.46	7	6.13	7
8	8.6	$\bar{2}1$	3.1	$\bar{5}$	4.8	0	1.88	3	6.76	4	7.4	5	4.05	6	1.46	7	3.95	7	8.75	7
9	1.4	$\bar{1}7$	9.3	$\bar{4}$	3.8	1	7.6	3	1.84	5	1.55	6	7.02	6	2.19	7	5.30	7	1.08	8
10	4.7	$\bar{1}5$	1.32	$\bar{2}$	1.87	2	2.21	4	3.89	5	2.63	6	1.03	7	2.87	7	6.36	7	1.204	8
12	2.7	$\bar{1}1$	6.3	$\bar{1}$	1.81	3	9.7	4	1.06	6	5.20	6	1.62	7	3.81	7	**7.42**	7	**1.264**	8
14	1.1	$\bar{8}$	8.9	0	8.1	3	2.46	5	1.92	6	7.50	6	1.99	7	**4.15**	7	7.36	7	1.167	8
16	9.8	$\bar{7}$	5.9	1	2.30	4	4.56	5	2.73	6	9.02	6	**2.13**	7	4.06	7	6.72	7	1.011	8
18	2.90	$\bar{5}$	2.39	2	4.84	4	6.84	5	3.36	6	9.76	6	2.10	7	3.73	7	5.87	7	8.47	7
20	4.14	$\bar{4}$	6.9	2	8.2	4	8.95	5	3.76	6	**9.83**	6	1.96	7	3.31	7	5.00	7	6.99	7
25	4.18	$\bar{2}$	4.00	3	1.82	5	1.233	6	**3.91**	6	8.49	6	1.490	7	2.289	7	3.22	7	4.26	7
30	7.68	$\bar{1}$	1.08	4	2.62	5	**1.295**	6	3.41	6	6.58	6	1.063	7	1.525	7	2.071	7	2.647	7
40	2.16	1	2.80	4	**3.07**	5	1.035	6	2.18	6	3.619	6	5.36	6	7.24	6	9.24	6	1.133	7
50	1.25	2	**3.85**	4	2.65	5	7.15	5	1.331	6	2.058	6	2.859	6	3.713	6	4.60	6	5.52	6
75	7.5	2	3.50	4	1.327	5	2.712	5	4.33	5	6.06	5	7.89	5	9.77	5	1.167	6	1.362	6
100	1.20	3	2.24	4	6.43	4	1.160	5	1.725	5	2.316	5	2.920	5	3.536	5	4.158	5	4.777	5

T	273		275		300		325		350		373		375		400		500		600	
λ	A	n	A	n	A	n	A	n	A	n	A	n	A	n	A	n	A	n	A	n
1.0	5.9	$\bar{8}$	8.8	$\bar{8}$	6.7	$\bar{6}$	2.6	$\bar{4}$	6.1	$\bar{3}$	7.6	$\bar{2}$	9.4	$\bar{2}$	1.03	$\bar{1}$	1.32	3	1.58	5
1.5	3.1	$\bar{1}$	4.0	$\bar{1}$	7.2	0	8.4	1	6.8	2	3.7	3	4.2	3	2.08	4	2.46	6	5.94	7
2.0	4.6	2	5.6	2	4.9	3	3.10	4	1.51	5	5.3	5	5.8	5	1.93	6	6.92	7	7.55	8
2.5	2.88	4	3.37	4	1.91	5	8.3	5	2.92	6	8.0	6	8.8	6	2.27	7	4.00	8	2.69	9
3.0	3.84	5	4.36	5	1.86	6	6.3	6	1.80	7	4.16	7	4.56	7	9.94	7	1.08	9	5.32	9
3.5	2.16	6	2.41	6	8.3	6	2.38	7	5.85	7	1.20	8	1.27	8	2.52	8	1.96	9	7.68	9
4	7.2	6	7.9	6	2.36	7	5.90	7	1.30	8	2.44	8	2.57	8	4.66	8	2.80	9	9.25	9
5	3.26	7	3.54	7	8.4	7	1.75	8	3.30	8	5.45	8	5.68	8	9.17	8	3.85	9	**1.006**	10
6	7.56	7	8.05	7	1.66	8	3.07	8	5.19	8	7.90	8	8.18	8	1.218	9	**4.04**	9	9.07	9
7	1.22	8	1.29	8	2.40	8	4.06	8	6.37	8	9.15	8	9.42	8	**1.327**	9	3.73	9	7.51	9
8	1.60	8	1.68	8	2.89	8	4.59	8	**6.81**	8	**9.36**	8	**9.61**	8	1.298	9	3.23	9	6.01	9
9	1.84	8	1.92	8	3.12	8	**4.71**	8	6.70	8	8.90	8	9.11	8	1.194	9	2.710	9	4.75	9
10	**1.96**	8	**2.03**	8	**3.14**	8	4.56	8	6.28	8	8.12	8	8.30	8	1.060	9	2.236	9	3.71	9
12	1.90	8	1.96	8	2.83	8	3.87	8	5.07	8	6.32	8	6.43	8	7.92	8	1.489	9	2.36	9
14	1.660	8	1.706	8	2.35	8	3.08	8	3.90	8	4.73	8	4.81	8	5.78	8	1.020	9	1.530	9
16	1.381	8	1.414	8	1.880	8	2.40	8	2.96	8	3.52	8	3.53	8	4.22	8	7.07	8	1.024	9
18	1.122	8	1.147	8	1.484	8	1.851	8	2.246	8	2.632	8	2.664	8	3.103	8	5.01	8	7.076	8
20	9.04	7	9.24	7	1.158	8	1.434	8	1.716	8	1.986	8	2.011	8	2.317	8	3.627	8	5.032	8
25	5.29	7	5.39	7	6.59	7	7.85	7	9.15	7	1.039	8	1.051	8	1.188	8	1.767	8	2.371	8
30	3.206	7	3.255	7	3.892	7	4.550	7	5.23	7	5.865	7	5.920	7	6.626	7	9.53	7	1.252	8
40	1.332	7	1.349	7	1.572	7	1.799	7	2.028	7	2.242	7	2.262	7	2.496	7	3.453	7	4.426	7
50	6.379	6	6.458	6	7.409	6	8.37	6	9.35	6	1.025	7	1.033	7	1.132	7	1.535	7	1.935	7
75	1.544	6	1.557	6	1.754	6	1.952	6	2.151	6	2.335	6	2.351	6	2.551	6	3.357	6	4.166	6
100	5.366	5	5.416	5	6.050	5	6.683	5	7.32	5	7.906	5	7.958	5	8.60	5	1.116	6	1.374	6

TABLE 2.—(*Continued*)

T	800		1 000		1 200		1 400		1 600		1 800		2 000		2 200		2 400		2 600		2 800	
λ	A	n	A	n	A	n	A	n	A	n	A	n	A	n	A	n	A	n	A	n	A	n
0.10	6	$\bar{5}\bar{8}$	2.1	$\bar{4}\bar{2}$	5.1	$\bar{3}\bar{2}$	1.3	$\bar{2}\bar{4}$	4.7	$\bar{1}\bar{9}$	1.0	$\bar{1}\bar{4}$	2.8	$\bar{1}\bar{1}$	1.9	$\bar{8}$	4.3	$\bar{6}$	4.3	$\bar{4}$	2.2	$\bar{2}$
0.20	1.5	$\bar{2}\bar{0}$	9	$\bar{1}\bar{3}$	1.4	$\bar{7}$	6.9	$\bar{4}$	4.1	$\bar{1}$	6.0	1	3.2	3	8.3	4	1.25	6	1.24	7	8.9	7
0.30	1.8	$\bar{8}$	2.7	$\bar{3}$	7.9	0	2.3	3	1.65	5	4.5	6	6.5	7	5.7	8	3.46	9	1.60	10	5.9	10
0.40	1.28	$\bar{2}$	1.00	2	3.9	4	2.8	6	6.8	7	8.2	8	6.0	9	3.08	10	1.19	11	3.75	11	1.00	12
0.41	3.4	$\bar{2}$	2.1	2	7.2	4	4.6	6	1.04	8	1.18	9	8.2	9	4.01	10	1.52	11	4.65	11	1.22	12
0.42	8.5	$\bar{2}$	4.3	2	1.27	5	7.4	6	1.56	8	1.65	9	1.10	10	5.2	10	1.90	11	5.6	11	1.45	12
0.43	2.04	$\bar{1}$	8.5	2	2.19	5	1.16	7	2.26	8	2.30	9	1.46	10	6.6	10	2.35	11	6.8	11	1.71	12
0.44	4.7	$\bar{1}$	1.61	3	3.7	5	1.78	7	3.24	8	3.10	9	1.91	10	8.4	10	2.87	11	8.2	11	2.00	12
0.45	1.04	0	3.0	3	6.0	5	2.67	7	4.6	8	4.17	9	2.45	10	1.04	11	3.47	11	9.6	11	2.31	12
0.46	2.2	0	5.3	3	9.5	5	3.9	7	6.3	8	5.46	9	3.09	10	1.27	11	4.15	11	1.13	12	2.64	12
0.47	4.5	0	9.2	3	1.49	6	5.6	7	8.5	8	7.2	9	3.87	10	1.54	11	4.93	11	1.30	12	3.01	12
0.48	9.1	0	1.57	4	2.28	6	8.0	7	1.14	9	9.2	9	4.77	10	1.86	11	5.75	11	1.50	12	3.41	12
0.49	1.74	1	2.60	4	3.42	6	1.11	8	1.51	9	1.15	10	5.9	10	2.22	11	6.7	11	1.71	12	3.82	12
0.50	3.3	1	4.2	4	5.0	6	1.53	8	1.97	9	1.44	10	7.1	10	2.60	11	7.7	11	1.94	12	4.23	12
0.51	6.0	1	6.7	4	7.3	6	2.08	8	2.54	9	1.79	10	8.5	10	3.05	11	8.8	11	2.17	12	4.73	12
0.52	1.06	2	1.05	5	1.04	7	2.74	8	3.22	9	2.20	10	1.01	11	3.52	11	1.01	12	2.43	12	5.18	12
0.53	1.85	2	1.60	5	1.45	7	3.60	8	4.07	9	2.65	10	1.19	11	4.07	11	1.13	12	2.69	12	5.67	12
0.54	3.16	2	2.40	5	2.02	7	4.7	8	5.1	9	3.18	10	1.40	11	4.66	11	1.27	12	2.97	12	6.17	12
0.55	5.3	2	3.50	5	2.74	7	6.1	8	6.3	9	3.80	10	1.62	11	5.30	11	1.42	12	3.27	12	6.69	12
0.56	8.6	2	5.2	5	3.7	7	7.7	8	7.6	9	4.50	10	1.86	11	5.98	11	1.58	12	3.58	12	7.22	12
0.57	1.38	3	7.5	5	5.0	7	9.8	8	9.2	9	5.29	10	2.14	11	6.68	11	1.74	12	3.89	12	7.8	12
0.58	2.19	3	1.05	6	6.4	7	1.22	9	1.11	10	6.2	10	2.44	11	7.5	11	1.91	12	4.21	12	8.3	12
0.59	3.38	3	1.46	6	8.4	7	1.51	9	1.33	10	7.1	10	2.76	11	8.3	11	2.09	12	4.54	12	8.9	12
0.60	5.2	3	2.02	6	1.08	8	1.86	9	1.56	10	8.2	10	3.10	11	9.2	11	2.27	12	4.89	12	9.4	12
0.61	7.8	3	2.76	6	1.38	8	2.26	9	1.85	10	9.4	10	3.47	11	1.01	12	2.46	12	5.23	12	1.00	13
0.62	1.15	4	3.70	6	1.75	8	2.73	9	2.15	10	1.07	11	3.87	11	1.10	12	2.66	12	5.57	12	1.05	13
0.63	1.68	4	4.96	6	2.18	8	3.27	9	2.50	10	1.21	11	4.29	11	1.21	12	2.86	12	5.93	12	1.11	13
0.64	2.41	4	6.5	6	2.71	8	3.92	9	2.88	10	1.36	11	4.74	11	1.31	12	3.06	12	6.28	12	1.16	13
0.65	3.44	4	8.5	6	3.36	8	4.61	9	3.31	10	1.53	11	5.21	11	1.42	12	3.28	12	6.64	12	1.22	13
0.66	4.83	4	1.10	7	4.08	8	5.5	9	3.78	10	1.71	11	5.71	11	1.53	12	3.49	12	6.99	12	1.27	13
0.67	6.7	4	1.41	7	5.0	8	6.4	9	4.30	10	1.90	11	6.22	11	1.64	12	3.70	12	7.34	12	1.32	13
0.68	9.3	4	1.80	7	6.0	8	7.4	9	4.86	10	2.10	11	6.76	11	1.76	12	3.92	12	7.7	12	1.37	13
0.69	1.25	5	2.27	7	7.2	8	8.6	9	5.5	10	2.31	11	7.32	11	1.88	12	4.14	12	8.0	12	1.42	13
0.70	1.69	5	2.84	7	8.6	8	9.9	9	6.1	10	2.53	11	7.91	11	2.00	12	4.36	12	8.4	12	1.47	13
0.71	2.26	5	3.52	7	1.02	9	1.13	10	6.8	10	2.77	11	8.52	11	2.13	12	4.57	12	8.7	12	1.52	13
0.72	3.00	5	4.35	7	1.21	9	1.28	10	7.6	10	3.02	11	9.12	11	2.26	12	4.79	12	9.1	12	1.57	13
0.73	3.96	5	5.3	7	1.40	9	1.45	10	8.4	10	3.28	11	9.76	11	2.38	12	5.01	12	9.4	12	1.61	13
0.74	5.14	5	6.5	7	1.64	9	1.64	10	9.2	10	3.55	11	1.04	12	2.51	12	5.23	12	9.7	12	1.66	13
0.75	6.6	5	7.9	7	1.90	9	1.84	10	1.02	11	3.83	11	1.11	12	2.64	12	5.44	12	1.00	13	1.70	13
0.76	8.5	5	9.4	7	2.19	9	2.06	10	1.11	11	4.12	11	1.18	12	2.77	12	5.66	12	1.04	13	1.74	13
0.77	1.08	6	1.13	8	2.52	9	2.31	10	1.22	11	4.42	11	1.24	12	2.90	12	5.87	12	1.07	13	1.78	13
0.78	1.36	6	1.34	8	2.90	9	2.56	10	1.32	11	4.74	11	1.32	12	3.03	12	6.08	12	1.10	13	1.82	13
0.79	1.72	6	1.61	8	3.26	9	2.84	10	1.44	11	5.06	11	1.39	12	3.16	12	6.28	12	1.12	13	1.85	13
0.80	2.13	6	1.88	8	3.71	9	3.14	10	1.55	11	5.39	11	1.46	12	3.29	12	6.49	12	1.15	13	1.89	13
0.90	1.43	7	7.6	8	1.08	10	7.21	10	2.99	11	9.03	11	2.19	12	4.51	12	8.25	12	1.38	13	2.14	13
1.00	6.17	7	2.21	9	2.41	10	1.33	11	4.78	11	1.29	12	2.86	12	5.50	12	**9.47**	12	**1.50**	13	**2.23**	13
1.50	3.18	9	3.46	10	1.70	11	5.30	11	1.25	12	**2.43**	12	**4.15**	12	**6.44**	12	9.27	12	1.269	13	1.662	13
2.00	1.49	10	8.96	10	2.96	11	**6.98**	11	**1.33**	12	2.20	12	3.31	12	4.63	12	6.16	12	7.85	12	9.71	12
2.50	2.94	10	1.23	11	**3.22**	11	6.43	11	1.08	12	1.64	12	2.29	12	3.03	12	3.79	12	4.70	12	5.62	12
3.00	3.90	10	**1.29**	11	2.90	11	5.20	11	8.11	11	1.15	12	1.52	12	1.961	12	2.412	12	2.888	12	3.38	12
4.00	**4.16**	10	1.04	11	1.93	11	3.03	11	4.31	11	5.72	11	7.24	11	8.83	11	1.048	12	1.219	12	1.395	12
5.00	3.39	10	7.15	10	1.19	11	1.76	11	2.37	11	3.03	11	3.71	11	4.421	11	5.15	11	5.89	11	6.64	11
10.00	7.41	9	1.16	10	1.61	10	2.08	10	2.56	10	3.04	10	3.54	10	4.033	10	4.53	10	5.04	10	5.54	10

TABLE 2.—(*Continued*)

T	3 000		4 000		5 000		6 000		7 000		8 000		9 000		10 000		15 000		20 000		25 000	
λ	A	n	A	n	A	n	A	n	A	n	A	n	A	n	A	n	A	n	A	n	A	n
0.10	6.7	$\bar{1}$	1.02	5	1.32	8	1.57	10	4.8	11	6.2	12	4.51	13	2.21	14	2.63	16	2.86	17	1.204	18
0.20	4.9	8	1.92	11	6.9	12	7.5	13	4.1	14	1.49	15	4.04	15	8.95	15	**9.84**	16	**3.31**	17	6.98	17
0.30	1.86	11	9.9	12	1.08	14	5.32	14	1.66	15	3.90	15	**7.59**	15	**1.296**	16	6.58	16	1.525	17	2.647	17
0.40	2.36	12	4.66	13	2.80	14	9.25	14	2.18	15	**4.16**	15	6.88	15	1.034	16	3.62	16	7.24	16	1.133	17
0.41	2.79	12	5.13	13	2.95	14	9.46	14	2.18	15	4.10	15	6.72	15	1.000	16	3.44	16	6.74	16	1.049	17
0.42	3.26	12	5.60	13	3.08	14	9.68	14	**2.18**	15	4.04	15	6.54	15	9.66	15	3.25	16	6.29	16	9.71	16
0.43	3.77	12	6.06	13	3.21	14	9.79	14	2.18	15	3.97	15	6.37	15	9.32	15	3.06	16	5.86	16	9.02	16
0.44	4.33	12	6.54	13	3.34	14	9.91	14	2.16	15	3.90	15	6.19	15	9.00	15	2.89	16	5.48	16	8.38	16
0.45	4.93	12	7.00	13	3.45	14	9.98	14	2.14	15	3.82	15	6.01	15	8.67	15	2.732	16	5.13	16	7.79	16
0.46	5.56	12	7.46	13	3.54	14	1.006	15	2.12	15	3.74	15	5.83	15	8.35	15	2.578	16	4.80	16	7.26	16
0.47	6.25	12	7.91	13	3.64	14	1.010	15	2.10	15	3.66	15	5.64	15	8.04	15	2.435	16	4.49	16	6.76	16
0.48	6.93	12	8.35	13	3.72	14	**1.011**	15	2.07	15	3.57	15	5.47	15	7.73	15	2.300	16	4.21	16	6.32	16
0.49	7.65	12	8.77	13	3.79	14	1.010	15	2.04	15	3.48	15	5.29	15	7.44	15	2.176	16	3.96	16	5.90	16
0.50	8.41	12	9.16	13	3.85	14	1.008	15	2.01	15	3.39	15	5.12	15	7.15	15	2.058	16	3.714	16	5.52	16
0.51	9.18	12	9.56	13	3.91	14	1.002	15	1.97	15	3.30	15	4.95	15	6.87	15	1.947	16	3.488	16	5.17	16
0.52	9.99	12	9.92	13	3.95	14	9.96	14	1.94	15	3.21	15	4.78	15	6.61	15	1.846	16	3.282	16	4.84	16
0.53	1.08	13	1.03	14	3.98	14	9.89	14	1.90	15	3.12	15	4.62	15	6.35	15	1.746	16	3.089	16	4.54	16
0.54	1.16	13	1.06	14	4.01	14	9.79	14	1.86	15	3.03	15	4.46	15	6.10	15	1.657	16	2.910	16	4.266	16
0.55	1.24	13	1.09	14	4.04	14	9.72	14	1.82	15	2.95	15	4.31	15	5.87	15	1.572	16	2.745	16	4.009	16
0.56	1.33	13	1.12	14	4.05	14	9.58	14	1.78	15	2.86	15	4.16	15	5.64	15	1.492	16	2.589	16	3.771	16
0.57	1.41	13	1.15	14	4.06	14	9.46	14	1.745	15	2.78	15	4.01	15	5.43	15	1.417	16	2.447	16	3.547	16
0.58	1.50	13	1.18	14	**4.06**	14	9.34	14	1.703	15	2.70	15	3.87	15	5.21	15	1.347	16	2.313	16	3.345	16
0.59	1.58	13	1.20	14	4.05	14	9.20	14	1.665	15	2.61	15	3.74	15	5.00	15	1.279	16	2.187	16	3.154	16
0.60	1.66	13	1.22	14	4.05	14	9.06	14	1.623	15	2.53	15	3.60	15	4.80	15	1.217	16	2.071	16	2.978	16
0.61	1.74	13	1.24	14	4.03	14	8.92	14	1.584	15	2.46	15	3.48	15	4.62	15	1.158	16	1.961	16	2.812	16
0.62	1.82	13	1.26	14	4.01	14	8.77	14	1.547	15	2.381	15	3.36	15	4.45	15	1.103	16	1.858	16	2.660	16
0.63	1.90	13	1.28	14	3.99	14	8.62	14	1.507	15	2.308	15	3.24	15	4.28	15	1.049	16	1.762	16	2.516	16
0.64	1.98	13	1.29	14	3.96	14	8.47	14	1.469	15	2.235	15	3.13	15	4.11	15	9.99	15	1.671	16	2.381	16
0.65	2.06	13	1.30	14	3.93	14	8.31	14	1.429	15	2.165	15	3.01	15	3.96	15	9.53	15	1.587	16	2.256	16
0.66	2.13	13	1.30	14	3.91	14	8.16	14	1.393	15	2.099	15	2.91	15	3.81	15	9.10	15	1.508	16	2.139	16
0.67	2.20	13	1.31	14	3.86	14	7.99	14	1.357	15	2.032	15	2.81	15	3.66	15	8.67	15	1.433	16	2.027	16
0.68	2.27	13	1.32	14	3.82	14	7.84	14	1.319	15	1.970	15	2.713	15	3.52	15	8.28	15	1.363	16	1.925	16
0.69	2.34	13	1.325	14	3.78	14	7.68	14	1.286	15	1.908	15	2.614	15	3.39	15	7.91	15	1.297	16	1.829	16
0.70	2.40	13	1.327	14	3.74	14	7.51	14	1.250	15	1.848	15	2.525	15	3.26	15	7.55	15	1.235	16	1.737	16
0.71	2.46	13	1.330	14	3.69	14	7.37	14	1.217	15	1.790	15	2.437	15	3.14	15	7.23	15	1.178	16	1.653	16
0.72	2.52	13	**1.332**	14	3.64	14	7.20	14	1.184	15	1.735	15	2.356	15	3.03	15	6.91	15	1.123	16	1.573	16
0.73	2.58	13	1.329	14	3.59	14	7.05	14	1.151	15	1.682	15	2.274	15	2.918	15	6.61	15	1.071	16	1.497	16
0.74	2.63	13	1.329	14	3.54	14	6.90	14	1.121	15	1.627	15	2.195	15	2.812	15	6.33	15	1.022	16	1.428	16
0.75	2.68	13	1.326	14	3.49	14	6.74	14	1.089	15	1.561	15	2.120	15	2.710	15	6.06	15	9.76	15	1.360	16
0.76	2.73	13	1.321	14	3.44	14	6.59	14	1.059	15	1.527	15	2.047	15	2.610	15	5.80	15	9.32	15	1.297	16
0.77	2.77	13	1.317	14	3.39	14	6.44	14	1.030	15	1.482	15	1.979	15	2.518	15	5.56	15	8.91	15	1.238	16
0.78	2.82	13	1.313	14	3.34	14	6.30	14	1.003	15	1.436	15	1.916	15	2.431	15	5.34	15	8.52	15	1.183	16
0.79	2.86	13	1.304	14	3.28	14	6.15	14	9.75	14	1.391	15	1.850	15	2.342	15	5.12	15	8.15	15	1.129	16
0.80	2.89	13	1.298	14	3.23	14	6.01	14	9.48	14	1.348	15	1.788	15	2.261	15	4.91	15	7.80	15	1.079	16
0.90	3.12	13	1.193	14	2.71	14	4.75	14	7.19	14	9.93	14	1.289	15	1.602	15	3.316	15	5.15	15	7.04	15
1.00	**3.15**	13	1.059	14	2.235	14	3.70	14	5.49	14	7.413	14	9.46	14	1.161	15	2.316	15	3.537	15	4.784	15
1.50	2.11	13	4.88	13	8.47	13	1.245	14	1.672	14	2.120	14	2.578	14	3.049	14	5.476	14	7.96	14	1.048	15
2.00	1.162	13	2.316	13	3.626	13	5.03	13	6.49	13	7.99	13	9.51	13	1.105	14	1.889	14	2.687	14	3.487	14
2.50	6.59	12	1.187	13	1.768	13	2.372	13	2.990	13	3.622	13	4.258	13	4.899	13	8.15	13	1.143	14	1.471	14
3.00	3.892	12	6.63	12	9.53	12	1.252	13	1.558	13	1.862	13	2.176	13	2.489	13	4.065	13	5.651	13	7.24	13
4.00	1.572	12	2.497	12	3.454	12	4.419	12	5.410	12	6.40	12	7.40	12	8.40	12	1.341	13	1.844	13	2.348	13
5.00	7.41	11	1.132	12	1.531	12	1.935	12	2.343	12	2.752	12	3.160	12	3.572	12	5.626	12	7.70	12	9.76	12
10.00	6.05	10	8.60	10	1.116	11	1.373	11	1.630	11	1.888	11	2.144	11	2.404	11	3.666	11	4.988	11	6.277	11

TABLE 3.—EFFECT OF A CHANGE IN C_2

If dJ_λ = increase produced in J_λ by an infinitesimal increase (dC_2) in C_2, then $(dJ_\lambda)/J_\lambda = -K(dC_2)/C_2$; for the units of Table 2 and $C_2 = 1.433$ cm, °K, K has the appropriate value tabulated below. *Example:* If $C_2 = 1.433$ cm, °K, then, at 300°K and $\lambda = 2\mu$, $J_\lambda = 4900$ (Table 2) and $K = 24$ (Table 3); hence, if $C_2 = 1.434$, $(dC_2)/C_2 = 0.0007$, $(dJ_\lambda)/J_\lambda = -24(0.0007) = -0.017$, $dJ_\lambda = -(0.017)(4900) = -83$ and $J_\lambda = 4900 - 83 = 4817$. Unit of $\lambda = 1\mu = 10^4$Å $= 10^{-4}$ cm; T = absolute temperature, °K.

λ	1	2	3	4	5	6	7	8	9	10	15	20	100	λ	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	2	3	4	5
T	K													T	K													
25	573	287	191	143	115	96	82	72	64	57	34	29	6	800	179	90	60	45	36	30	26	22	20	18	9	6	4	4
50	287	143	96	72	57	48	41	36	32	29	17	14	3	1 000	143	72	48	36	29	24	20	18	16	14	7	5	3	3
75	191	96	64	48	38	32	27	24	21	19	11	10	2	1 500	96	48	32	24	20	16	14	12	10	10	5	3	3	3
100	143	72	48	36	29	24	20	18	16	14	8	7	2	2 000	72	36	24	18	14	12	10	9	8	7	5	2	2	2
200	72	36	24	18	14	12	10	9	8	7	4	3	1	3 000	48	24	15	12	10	8	7	6	6	5	3	2	1	1
250	57	29	19	14	11	10	8	7	6	6	3	3	1	4 000	36	18	12	9	7	6	5	4	4	3	2	1	1	1
300	47	24	16	12	10	8	7	6	6	5	3	3	1	5 000	29	14	8	7	6	5	4	3	3	3	2	1	1	1
350	40	20	13	11	8	7	6	5	4	4	3	2	1	7 500	20	9	6	5	4	3	3	3	2	2	1	1	1	1
400	36	18	12	9	7	6	5	4	4	3	3	2	1	10 000	14	7	5	3	3	3	2	2	2	2	1	1	1	1
500	29	14	10	7	6	5	4	3	3	3	2	2	1	20 000	7	3	3	2	2	1	1	1	1	1	1	1	1	1
600	24	12	8	6	5	4	3	3	3	3	2	1	1	25 000	6	3	2	2	1	1	1	1	1	1	1	1	1	1

THERMAL RADIATION FROM MATERIALS AND SELECTED SOURCES OF RADIATION

W. W. COBLENTZ

For radiation from a "black-body," *see* p. 238.

At wave-length λ, the monochromatic intensity of the normal radiation of a body is $J_{n\lambda}$, where $J_{n\lambda}d\lambda$ = amount of radiant energy, having wave-lengths lying between $(\lambda - 0.5d\lambda)$ and $(\lambda + 0.5d\lambda)$, which the body emits in a direction perpendicular to its radiating surface per unit of time, of surface, and of solid angle; $J_n = \int_0^\infty J_{n\lambda}d\lambda$ is the normal intensity of the total radiation of the body. If the emission satisfies Lambert's law, as is the case for the substances here considered, the hemispherical intensity of the total radiation is $J = \pi J_n$ = total emission per unit of time and of area, and the monochromatic intensity of the hemispherical radiation is $J_\lambda = \pi J_{n\lambda}$. If the corresponding quantities for a perfect radiator (black-body) at the same temperature be indicated by J_b and $J_{\lambda b}$, and if $e_\lambda \equiv J_\lambda/J_{\lambda b}$ and $e_t \equiv J/J_b$, then e_λ and e_t are, respectively, the monochromatic and the total emissivity of the body. If J_c = value of the hemispherical intensity of the total radiation of a black-body at such a temperature that it has the same color as that of the body considered, $e_c \equiv J/J_c$ is the color emissivity of the body; and if $e_v \equiv \left(\int_{\lambda_1}^{\lambda_2} J_\lambda d\lambda\right) \div \left(\int_{\lambda_1}^{\lambda_2} J_{\lambda b} d\lambda\right)$, where λ_1 and λ_2 mark the limits of visible spectrum (about 0.4μ and 0.75μ), e_v is the visible emissivity. The Crova wave-length is that at which $\frac{1}{J_\lambda}\frac{dJ_\lambda}{dT} = \frac{1}{J}\frac{dJ}{dT}$. Usually the quantities directly observed are $J_{n\lambda}$ and J_n, and J_λ and J are computed from them on the assumption that Lambert's law is valid.

TABLE 1.—MONOCHROMATIC EMISSIVITY ($e\lambda$) OF ELEMENTARY SUBSTANCES AND OXIDES: TEMPERATURE OF FUSION(1)

Assumes $C_2 = 14\,450$ micron °C. A micropyrometer was used. s = solid, l = liquid. Unit of $e_\lambda = 0.01 = 1\%$; of $\lambda = 1\mu = 0.001$ mm $= 10000$ Å.

λ =	0.55		0.65		λ =	0.55		0.65	
Symbol	s	l	s	l	Symbol	s	l	s	l
Ag*	<35	<35	4	7	Cr	53		39	39
Au*	<38	<38	14	22	Cu*	38	36	10	15
Be	61	81	61	61	Er		30	55	38
Cb	61		49	40	Fe			37	37
Co			36	37	Ir			30	
Mn			59	59	BeO			37	
Mo*			43	40	CbO_x			71	
Ni	44	46	36	37	Co_3O_4			77	63
Pd	38		33	37	Cr_2O_3			60	
Pt*	38		33	38	Fe_3O_4			63	53
Rh			29	30	Mn_3O_4				47
Th	36		36	40	NiO			89	68
Ti	75	75	63	65	ThO_2			57	69
U	77		54	34	TiO_2			52	51
V	29		35	32	U_3O_8			30	31
W*			39		V_2O_3			69	
Yt			35	35	Yt_2O_3			61	
Zr			32	30					

* *See also* Table 2.

TABLE 2.—EMISSIVITY AND HEMISPHERICAL RADIATION: AG, AL, AU, CU, MO, PT, AND W

$e\lambda$, e_c, e_v and e_t = monochromatic, color, visible, and total emissivity, respectively. λ = wave-length; s, l = solid, liquid; M. P. = melting point; J_λ = monochromatic intensity of hemispherical radiation; J = hemispherical intensity of total radiation; t, T = temperature, °C, °K(absolute). Unit of e_λ, e_c, e_v, e_t = $0.01 = 1\%$; of $J = 1$ watt cm^{-2}; of $\lambda = 1$ m$\mu = 10^{-7}$ cm.

Ag, liquid* (16)			Au (17)			Cu, Solid (16)			Liquid*	
t =	1060°	1117°	t =	949° / 1061°	1067° / 1177°	t =	991°	1035°	1090°	1174°
λ	e_λ	e_λ	λ	$e_\lambda s$	$e_\lambda l$	λ	e_λ	e_λ	e_λ	e_λ
			475.0		50.3					
500	8.17	9.48	496.1	53.1	47.3	500	38.9	42.1	37.4	40.2
525	8.49	9.03	518.6	49.5	43.4	525	35.5	36.7	33.0	34.9
550	8.06	8.27	541.8	37.1	39.0	550	30.8	31.9	29.8	28.6
575	7.75	7.74	564.9	30.1	34.7	575	23.7	25.7	25.1	24.4
600	7.17	7.58	589.5	22.9	30.4	600	17.3	20.1	21.0	19.7
625	6.97	7.37	614.9	17.4	26.3	625	13.0	15.0	17.1	16.7
650	7.22	7.30	640.9	14.4	23.2	650	10.4	12.4	14.8	14.6
675	6.90	7.41	671.2	11.5	20.3	675	9.5	11.1	12.3	13.0
700	6.66	7.21	701.4	10.3	18.4	700	7.7	9.4	10.6	12.4
(1)	M. P. s	M. P. l	(1)	M. P. s	M. P. l	(1)	M. P. s		M. P. l	
550	<35	<35	550	<38	<38	550	38		36	
650	4	7	650	14	22	650	10		15	

Al, liquid	t	700	800	850	900	950	1000	(12.1)
$\lambda = 650$	e_λ	12	12	13	14	15	17	

Mo ([18]), assumes $C_2 = 14\,330$ micron deg.; M. P. of Au = 1336°K

λ = 475		665	Visible	Color	Total	J	$\frac{T}{J'}\frac{dJ}{dT}$
T	e_λ	e_λ	e_v	e_c	e_t		
273	42.5	42.0					
300	42.4	41.9					
400	42.1	41.5					
600	41.5	40.6					
800	40.9	39.8					
1000	40.3	39.0	39.3	36.1	9.6	0.55	5.32
1200	39.8	38.2	38.6	34.7	12.1	1.43	5.23
1400	39.3	37.5	37.9	33.3	14.5	3.18	5.16
1600	38.8	36.7	37.3	32.1	16.8	6.30	5.10
1800	38.3	36.0	36.7	30.9	18.9	11.3	5.04
2000	37.9	35.3	36.2	29.7	21.0	19.2	4.99
2200	37.5	34.7	35.7	28.7	23.0	30.7	4.94
2400	37.1	34.1	35.2	27.7	24.8	47.0	4.90
2600	36.8	33.6	34.8	26.8	26.5	69.5	4.86
2800	36.5	33.1	34.4	26.0	28.1	98	4.83
2895	36.3	32.8	34.2	25.5	29.0	116	4.81

Mo, at M. P. and $\lambda = 650$; solid, $e_\lambda = 43$; liquid $e_\lambda = 40$ ([1])

Pt, intensity (J_λ) of monochromatic radiance; unit of J_λ = (arbitrary) ([3])

λ	t = 1056°	1174°	1216°	1271°	1353°	1442°
589						43.30
646						118.4
698			31.51	36.42	34.92	187.9
757		16.49	55.73	55.02	65.60	293.6
836	11.52	31.19	101.3	105.0	107.8	501.1
934	26.79	56.85	200.1	212.6	201.6	772.1
1054	52.46	101.7	319.5	339.9	314.0	1141
1197	85.60	167.2	459.1	494.1	425.0	1395
1357	126.7	234.8	603.1	615.6	514.2	1544
1526	166.4	275.2	680.4	692.1	569.8	1560
1698	176.9	289.2	676.1	682.0	567.6	1409
1868	188.5	287.0	646.0	658.3	528.1	1302
2033	187.8	276.9	617.7	614.1	492.3	1135
2190	176.2	253.9	548.3	559.9	441.5	1014
2410	158.5	225.4	462.0	469.1	380.2	835.8
2546	141.1	197.4	399.7	408.1	350.0	712.2
2801	115.1	152.5	321.7	313.0	251.2	538.6
2921	103.4	139.4	284.2	279.3	224.2	464.3
3037	94.76	123.1	252.0	255.4	206.9	426.6
3150	84.61	115.9	232.1	235.9	191.0	384.5
3367	77.10	99.78	211.6	202.3	158.3	328.1
3569	70.93	89.82	178.0	174.7	137.7	283.5
3760	64.54	75.19	149.6	155.6	120.0	252.2
4031	50.80	67.03	121.2	125.7	103.6	198.5
4446	40.09	47.78	96.99	96.80	74.86	147.2
4638	35.78	42.84	84.12	85.05	65.90	129.3
4827	29.50	38.06	74.64	72.13	55.93	111.4
5001	28.30	34.00	62.53	64.46	50.40	101.1
5168	25.20	30.63	56.00	57.26	46.92	88.60
5486		26.52	40.39	48.46	36.32	75.35
6240			27.61	30.59	25.12	41.72

Pt, (J_λ) ([3]).—*(Continued)*

λ	t = 1481°	1625°	1691°
589	37.38	126.0	162.4
646	94.80	257.1	295.0
698	154.6	348.9	461.9
757	237.3	549.5	724.7
836	382.4	830.3	1064
934	581.9	1176	1436
1054	859.2	1639	1815
1197	1073	1840	2096
1357	1217	1929	2225
1526	1225	1901	2140
1698	1143	1728	1885
1868	1047	1528	1675
2033	932.4	1238	1442
2190	830.3	1156	1279
2410	699.8	869.0	1015
2546	624.0	811.4	841.7
2801	444.8	599.5	640.5
2921	394.0	530.5	563.0
3037	364.0	460.0	497.3
3150	318.8	432.5	445.6
3367	270.8	358.0	362.8
3569	238.5	292.9	315.0
3760	206.0	265.0	273.2
4031	168.8	225.1	217.2
4446	123.8	152.0	158.7
4638	105.0	140.0	140.8
4827	92.60	125.3	114.2
5001	80.22	105.0	107.4
5168	75.79	90.61	98.79
5486	61.34	69.20	78.81
6240	35.81	38.66	44.92
6852	22.50	25.64	29.28

For platinum black, *see* Table 4.

Pt, total emissivity† ([7])

T	$e_{calc.}$	$e_{obs.}$
300	4.11	3.59
350	4.77	4.10
400	5.43	4.66
450	6.06	5.30
500	6.68	5.98
550	7.29	6.71
600	7.90	7.50
650	8.48	8.25
700	9.07	9.05
750	9.61	9.79
800	10.14	10.52
850	10.7	11.3
900	11.2	12.0
950	11.7	12.7
1000	12.2	13.4
1050	12.7	14.1
1100	13.2	14.7
1150	13.7	15.3
1200	14.1	15.9
1250	14.6	16.5
1300	15.0	17.1
1350	15.5	17.6
1400	15.9	18.2
1450	16.3	18.7
1500	16.7	19.2

Pt, monochromatic emissivity

λ	536	647
e_λ‡ ([10])	36.3	34.8
λ	550	650
e_λ ([1])	38	33 *s*
t = M. P.		38 *l*

W ([18]), data apply to aged tungsten filaments

λ =	467	665	Visible	Color	Total	Crova	J	$\frac{T}{J'}\frac{dJ}{dT}$
T	e_λ	e_λ	e_v	e_c	e_t	λ_c		
300	50.5	47.0			3.2		0.0015	
400	50.1	46.8			4.2		0.006	
500	49.8	46.6			5.3		0.019	
600	49.5	46.4			6.4		0.048	
700	49.2	46.2			7.6		0.105	
800	49.0	46.0			8.8		0.206	
900	48.8	45.8			10.1		0.379	
1000	48.6	45.6	46.4	39.6	11.4	607.7	0.654	5.35
1100	48.4	45.4	46.3	39.3	12.8	603.8	1.072	5.35
1200	48.2	45.2	46.2	39.1	14.4	600.4	1.691	5.35
1300	48.0	45.0	46.0	38.8	15.8	597.1	2.576	5.35
1400	47.8	44.8	45.9	38.6	17.4	593.4	3.82	5.29
1500	47.6	44.5	45.7	38.3	19.2	590.2	5.55	5.23
1600	47.5	44.3	45.6	38.1	20.7	587.4	7.77	5.15
1700	47.3	44.1	45.5	37.8	22.2	585.0	10.59	5.07
1800	47.2	43.9	45.4	37.6	23.6	582.6	14.22	4.99
1900	47.0	43.7	45.3	37.3	24.9	580.6	18.25	4.91
2000	46.9	43.5	45.2	37.0	26.0	578.5	23.72	4.85
2100	46.7	43.3	45.0	36.7	27.0	576.9	29.86	4.79
2200	46.6	43.1	44.9	36.4	27.9	575.3	37.18	4.74
2300	46.4	42.9	44.8	36.2	28.8	573.7	45.9	4.69
2400	46.3	42.7	44.7	35.9	29.6	572.4	55.8	4.64

W (18).—(*Continued*)

λ =	467	665	Visible	Color	Total	Crova	J	$\frac{T}{J}\frac{dJ}{dT}$
T	e_λ	e_λ	e_v	e_c	e_t	λ_c		
2500	46.2	42.5	44.6	35.6	30.2	571.1	67.6	4.59
2600	46.0	42.3	44.4	35.3	31.1	570.1	80.8	4.55
2700	45.9	42.1	44.3	35.0	31.8	569.1	96.2	4.51
2800	45.8	41.9	44.2	34.7	32.3	568.2	112.9	4.47
2900	45.6	41.7	44.1	34.5	32.9	567.4	132.1	4.43
3000	45.5	41.5	44.0	34.3	33.4	566.6	153.9	4.40
3100	45.4	41.3	43.8	34.1	33.7	565.9	177.5	4.37
3200	45.2	41.1	43.7	33.8§	34.1§	565.2	203	4.34
3300	45.1	40.9	43.6	33.5§	34.4§	564.5	232	4.31
3400	45.0§	40.7§	43.5§	33.2§	34.8§	563.8	264§	4.29
3500	44.9§	40.5§	43.4§	32.9§	35.1§	563.1	300§	4.27
3655	44.7§	40.2§	43.3§	32.4§	35.4§	562.1	360§	

W, t = 2000 to 3200°C, e_λ = 49, same for λ = 536 as for λ = 647; independent of t (10); others (8, 12) have found e_λ varies with t. For solid W at M. P., λ = 650, e_λ = 39 (1).

* Fused in H.

† Radiator was a Pt wire in a highly evacuated enclosure; $e_{calc.} = 0.751 \times \sqrt{T_\rho} - 0.632 T_\rho + 0.670 (T_\rho)^{\frac{3}{2}} - 0.607 (T_\rho)^2$, where ρ = resistivity (ohm-cm), and T = absolute temperature (°K); $e_{obs.}$ = observed emissivity.

‡ Between 20°C and 1710°C, e^λ is independent of t.

§ Extrapolated values.

TABLE 3.—TOTAL EMISSIVITY (e_t) OF OXIDIZED METALS (15)

Surfaces were oxidized at $t \leqq$ 600°C; Unit of e_t = 0.01 = 1%

Metal	200°C	400°C	600°C
Ag, Silver	2.0	3.0	3.8
Al, Aluminum*	11.3	15.3	19.2
Cu, Copper†	18.0	18.5	19.0
Cu, Copper*	56.8	56.8	56.8
Cu-Zn, Brass*	61.0	60.0	58.9
Fe, Cast iron	21.0		
Fe, Cast iron*	64.3	71.0	77.7
Steel†	52.1	54.7	57.0
Steel*	79.0	78.8	78.7
Ni, Nickel*	36.9	42.4	47.8
Ni-Cu, Monel*	41.1	43.9	46.3
Pb, Lead*	63.1		
Pt, Platinum	6.0	8.6	11.0
Zn, Zinc*		11.0	

* Oxidized. † Calorized surface.

TABLE 4.—TOTAL EMISSIVITY (e_t) OF PLATINUM BLACK AND OF LAMPBLACK: VARIATION WITH THICKNESS (11)

Deposited upon Pt. The lampblack was covered with lacquer. D_s = surface density of the black. Unit of $D_s = 10^{-6}$ g cm^{-2} = 0.001 mg cm^{-2}; of e_t = 0.01 = 1%. Temperature = 100°C.

Pt Black		Lampblack	
D_s	e_t	D_s	e_t
37	7.8	22	33.0
150	12.9	25	40.7
224	23.4	79	58.0
257	31.1	79	64.0
286	46.5	90	72.9
327	58.5	97	77.6
412	72.9	126	82.5
599	89.3	173	89.8
827	93.5	242	93.1
942	94.2	267	94.9
1072	94.9	300	94.2
1140	95.3	332	94.5
1897	96.8	339	94.0
3185	96.7	527	93.1
		1182	88.2

TABLE 5.—EFFICIENCY OF COATED SHEETS AS SUN-SHIELDS, AND RELATIVE EMISSIVITIES OF PAINTS AND COATINGS (6)

While one side (upper) of a sheet was continuously exposed normally to the sun, the radiation (r) proceeding normally from the other side (lower) was measured. If r_1 and r_2 are simultaneous values for two sheets similarly exposed, r_2/r_1 measures the relative efficiency of the second with reference to the first; if the sheets are unperforated and are good thermal conductors, r_2/r_1 is the ratio of the emissivities of the two lower surfaces. All sheets were approximately at 50°C. Unit of r_2/r_1 = 0.01 = 1%.

	Sheet 1		Sheet 2		r_2/r_1
	Upper	Lower	Upper	Lower	
Sheet iron*	Asbestos	Asbestos	Asbestos	Al paint	55
			Al paint	Al paint	72
Iron, 6 mm†	Black‡	Oxidized	Al paint	Oxidized	50
			White lead	Oxidized	30
Iron, 0.5 mm†	Black	Al paint d.§	Black	Al paint p.§	100
	Black	White lead	Black	Lampblack	95, 100
			Black	Al paint	28, 29
			Black	Enamel‖	98, 100
	Black	Lampblack	Black	Enamel‖	95, 98
	Black	Enamel‖	Black	Al paint	27, 30
Cypress, 12.7 mm†	Unpainted	Unpainted	Unpainted	Al paint	43
Rubberized cloth¶	Rubber	Cloth	Al paint	Cloth	45
Leatheroid** (1)	Unpainted	Unpainted	Unpainted	Al paint	44
			Al paint	Unpainted	30
(2)	Unpainted	Unpainted	Unpainted	Al paint	39
			Al paint	Unpainted	25
(3)	Unpainted	Unpainted	Unpainted	Al paint	47
			Al paint	Unpainted	27
Duck, 11 H††	Unpainted	Unpainted	Unpainted	Al paint	14, 15
			Al paint	Unpainted	22, 23
Duck, 4 H††	Unpainted	Unpainted	Unpainted	Al paint	22, 25
Duck†† (12 H; 4 H)‡‡	Unpainted	Al paint	Unpainted	Al paint	80, 81
Duck†† (12 H; 4 H)‡‡	Unpainted	Unpainted	Unpainted	Unpainted	58

* Corrugated asbestos roofing. Temperature in shade = 29°C; temperature of sheet with asbestos on both sides = 44°C; asbestos upper, Al lower = 45°C; Al both sides = 52°C; Zn sprayed on both sides = 55°C.

† Thickness of sheet. ‡ Asphalt paint. § d., p. = dull, polished. ‖ White, vitreous enamel. ¶ Balloon fabric.

** Artificial leather: (1) Single fabric. (2) Double fabric enclosing thin layer of rubber-friction stock. (3) Similar to (2), but of double-texture fabric. All three were coated on upper side with a black, rubber composition.

†† Cotton duck; 11 H is 13.08 oz./yd.^{2}; 4 H is 24.54 oz./yd.^{2}; 12 H is 11.45 oz./yd.^{2}

‡‡ Sheet 1 is 12 H; sheet 2 is 4 H.

TABLE 6.—LOSS OF HEAT FROM VERTICAL BRICK WALL (2)

In still air at 21°C, the wall, at the surface temperature t, lost heat, from one side, at the rate E. E is the same for the natural color (red), for brick coated with $Ca(OH)_2$, and for brick coated with lampblack. Uncertainty in t is about 2%. Unit of E = 0.001 watt/cm^2 = 2.39×10^{-4} cal cm^{-2} sec^{-1} = 6.12×10^{-6} BTU in.$^{-2}$ sec^{-1}.

t	47°C	66°C	86°C	131°C	199°C	218°C
E	30.8	61.7	92.5	185	370	431

TABLE 7.—NORMAL IRRADIATION (R) BY HEFNER STANDARD LAMP AND BY SPERM CANDLE: DISTANCE = 1 METER

R = radiant power, per unit area of receiving surface, which is received by a surface which is normal to the direction of propagation of the radiation and 1 meter from the source. Unit of $R = 10^{-6}$ watt/cm^{-2} = 2.389×10^{-6} cal cm^{-2} sec^{-1} = 6.118×10^{-8} BTU in.$^{-2}$ sec^{-1}.

Source	R	Remarks	Lit.
1 Sperm candle	12.1		(4)
1 Hefner lamp	10.9*		(4)
	9.6†		(4)
	9.47†	Amyl acetate, ordinary	(9)
	9.40†	Amyl acetate, pure	(9)
	9.43†	Isoamyl acetate	(9)

* No diaphragm. † Diaphragm, opening 14 mm by 50 mm.

TABLE 8.—MONOCHROMATIC EMISSIVITY (e_λ) AND MONOCHROMATIC INTENSITY (J_λ) OF RADIATION OF WELSBACH GAS MANTLE (14)

The mantle contained 0.993 ThO_2 per 0.007 Ce_2O_3; J_λ depends upon relative amount of Ce_2O_3. e_λ is computed on assumption that true absolute temperature of mantle = 1800°K. Unit of λ = 1μ = 0.001 mm = 10^4Å; of J_λ = (arbitrary); of e_λ = 0.01 = 1%.

λ	J_λ	e_λ	λ	J_λ	e_λ	λ	J_λ	e_λ
0.45	3.8	86	1.5	34.0	0.9	8.0	23.9	21
0.50	11.5	72	2.0	25.5	0.7	9.0	29.9	39
0.55	22.0	49	3.0	17.0	0.9	10.0	27.4	52
0.60	24.0	24	4.0	7.6	0.8	12.0	19.1	70
0.70	25.8	6.2	5.0	7.0	1.4	15.0	8.9	79
1.0	34.3	1.9	6.0	7.9	2.7	18.0	5.0	81
1.2	34.3	1.2	7.0	15.0	8.4			

TABLE 9.—MONOCHROMATIC INTENSITY (J_λ) OF RADIATION FROM A CYLINDRICAL ACETYLENE FLAME (5)

The value of J_λ for a flat flame, whether viewed flatwise or edgewise, is different from that for a cylindrical flame. J'_λ is the intensity of the radiation from a black-body at 2360°K, assuming C_2 = 14350 micron °K. Unit of $\lambda = 10^{-3}\mu = 10^{-7}$ cm = 10 Å; of J_λ = of J'_λ = (arbitrary); of J_λ/J'_λ = 0.01 = 1%.

λ	J_λ	J'_λ	J'_λ/J_λ	λ	J_λ	J'_λ	J'_λ/J_λ
400	5	3.3	66	460	11.8	11.2	94.9
425	7	5.5	79	475	15.0	14.6	97.4
440	8.5	7.6	89.4	500	20.9	21.0	100.5
450	10.0	9.25	92.5	520	27.5	27.3	99.3
525	29.2	29.2	100.0	650	91.2	92.1	101.0
540	34.6	34.6	100.0	660	97.6	98.5	100.7
550	38.9	38.8	99.8	675	107.5	108.0	100.4
560	42.9	43.1	100.4	680	110.9	111.3	100.7
575	49.8	49.9	100.2	700	124.1	124.1	100.0
580	52.2	52.4	100.3	720	137.5	137.2	99.8
600	62.5	62.9	100.6	725	141.0	140.5	99.6
620	73.3	74.0	101.1	740	151.0	150.2	99.5
625	76.1	76.8	100.8	750	157.9	157.2	99.5
640	85.0	86.0	101.1	750	163.0	157.2	96.5

TABLE 10.—MONOCHROMATIC INTENSITY (J_λ) OF RADIATION OF A GAS-FILLED TUNGSTEN LAMP (13)

Color temperature = 2848°K; efficiency = 15.6 lumen per watt. Unit of $\lambda = 10^{-2}\mu = 10^{-6}$ cm = 100Å; of J_λ = (arbitrary).

λ =	40	42	44	46	48	50	52	54	56
J_λ =	35	45	57.5	73.5	94.0	116.5	141	167.5	196
λ =	58	60	62	64	66	68	70	72	74
J_λ =	224	252	280	307.5	336.5	365	393	421	450

LITERATURE

(For a key to the periodicals see end of volume)

(1) Burgess and Waltenberg, *31A*, **11**: 591; 15. (2) Celite Products Co., Chicago, Ill., *0*. (3) Coblentz, *31A*, **9**: 81; 12. (4) Coblentz, *31A*, **11**: 87; 15. (5) Coblentz, *31A*, **15**: 639; 20. (6) Coblentz and Hughes, *32*, No. **254**; 24. (7) Davisson and Weeks, *43*, **8**: 581; 24. (8) Foote, *128*, **6**: 317; 16. (9) Gerlach, *63*, **14**: 577; 13.
(10) Henning and Heuse, *96*, **16**: 63; 23. (11) Kurlbaum, *8*, **67**: 846; 99. (12) Langmuir, *2*, **7**: 302; 16. (12-1) Moeller and Miething, *Giesserei-Ztg.*, **21**: 444; 24. (13) Priest, *43*, **6**: 27; 22. (14) Rubens, *8*, **18**: 725; 05. **20**: 593; 06. (15) Randolph and Overholser, *2*, **2**: 144; 13. (16) Stubbs, *5*, **88**: 195; 13. (17) Stubbs and Prideaux, *5*, **87**: 451; 12. (18) Worthing, A. S., National Electric Lamp Assn., Nela Park, Cleveland, O., *0*.

TEMPERATURE, BRIGHTNESS AND EFFICIENCY OF SELECTED SOURCES OF LIGHT

W. E. FORSYTHE

(All data and computations not credited to another have been supplied by the Nela Research Laboratory, Cleveland, Ohio, U. S. A.)

Definitions

The *brightness temperature* of a body (B) for a stated wavelength (frequently, $\lambda = 0.665\mu$) is the temperature at which an ideal black-body has, at this wave-length, the same brightness as B.

The *color temperature* of a body (B) is the temperature at which an ideal black-body has the same integral (or apparent) color as B.

The *radiation temperature* of a body (B) is the temperature at which the rate of total energy radiation from an ideal black-body is equal to that from B.

By the *brightness* of a source is meant the brightness in the direction perpendicular to the emitting surface.

TABLE 1.—BRIGHTNESS TEMPERATURE ($\lambda = 0.665\mu$) CORRESPONDING TO TRUE TEMPERATURE T

T = true absolute temperature, °K

T	C* (8)	Mo (14)	Ni (14)	Pt (14)	Ta (14)	W (12)	Nernst glower (11)
1000	995	958	956	950	966	966	
1100	1092	1049	1047	1037	1058	1058	959
1200	1189	1139	1137	1124	1149	1149	1065
1300	1286	1228	1226	1211	1239	1240	1271
1400	1382	1316	1315	1296	1329	1330	1277
1500	1478	1403	1403	1381	1418	1420	1384
1600	1574	1489		1466	1506	1509	1491

T	C* (8)	Mo (14)	Ni (14)	Pt (14)	Ta (14)	W (12)	Nernst glower (11)
1700	1670	1574		1551	1592	1597	1598
1800	1766	1658		1634	1680	1684	1705
1900	1862	1741		1717	1766	1771	1814
2000	1958	1824		1800	1851	1857	1922
2100	2054	1905			1935	1943	2030
2200	2150	1986			2018	2026	2140
2300	2245	2065			2099	2109	2250
2400	2340	2143			2180	2192	2361
2500		2220			2260	2274	2472
2600		2297			2339	2356	
2700		2373			2417	2437	
2800		2448			2495	2516	
2900		2523			2571	2595	
3000					2647	2673	

T	Au (14)	Cu† (3)	Fe† (3)	FéO‡ (3)	Ni_2O_3‡ (3)	Ni-Cr§ (3)	Slag† (3)
1000	908			1000	999	997	
1100	990			1099	1098	1095	
1200	1071			1197	1196	1193	
1300	1151			1295	1292	1289	
1400		1255		1392	1389	1383	
1500		1335	1412	1489	1484	1475	

TABLE 1.—(*Continued*)

T	Au (14)	Cu† (3)	Fe† (3)	FeO‡ (3)	Ni_2O_3‡ (3)	Ni-Cr§ (3)	Slag† (3)
1600		1413	1499		1580		
1700		1490	1586				1646
1800		1566	1673				1738
1900			1759				1831
2000			1844				1924
2100			1929				
2200			2016				

* Untreated carbon filament.
† Molten.
‡ Solid.
§ Nichrome, chromel.

TABLE 2.—COLOR TEMPERATURE CORRESPONDING TO TRUE TEMPERATURE (T) (9) AND TABLE 1

T = true absolute temperature, °K

T	C*	Mo	Ni	Pt	Ta	W	Nernst glower
1000		1004	1020	1011		1006	
1100		1105	1125	1116		1108	
1200		1207	1231	1222		1210	
1300	1300	1309	1336	1328		1312	
1400	1396	1411	1442	1435		1414	
1500	1492	1513	1546	1542	1532	1517	1517
1600	1590	1616		1649	1642	1619	1631
1700	1687	1720		1757	1751	1722	1744
1800	1785	1823		1865	1859	1825	1857
1900	1884	1927		1974	1967	1929	1968
2000	1984	2032		2083	2075	2033	2074
2100	2086	2138			2182	2137	2173
2200	2187	2244			2288	2242	2265
2300	2288	2350			2393	2347	2345
2400		2456			2497	2452	2426
2500		2563			2601	2557	2502
2600		2672			2705	2663	
2800		2891			2911	2878	
3000						3094	

* Untreated carbon filament.

TABLE 3.—COLOR TEMPERATURE CORRESPONDING TO BRIGHTNESS TEMPERATURE (T_B) (9) AND TABLE 1

T_B = brightness temperature, absolute, °K

T_B	C*	C†	Os
1400	1414		1444
1500	1515		1562
1600	1616	1620	1680
1700	1718	1735	1799
1800	1820	1852	1919
1900	1923	1962	2045
2000	2028	2064	2168
2100	2134	2161	2295
2200	2240	2255	2427
2300			2556
2400			2688

* Untreated carbon filament.
† Treated carbon filament, "Gem."

TABLE 4.—RADIATION TEMPERATURE CORRESPONDING TO TRUE TEMPERATURE (T)

T = true absolute temperature, °K

T	Cu* (3)	CuO (3)	Fe* (3)	FeO (3)	Mo (14)	Ni_2O_3 (3)	Pt (13)	W (5)
1000		880		963	557	892	562	581
1100		961		1060	633	1003	632	659
1200		1156		1156	708	1112	704	738
1300	815	1245		1251	786	1220	775	819
1400	873	1334		1346	864	1332	849	905
1500	934	1424	1092	1442	945	1442	922	991
1600	1000	1514	1163		1024		995	1080
1700			1235		1106		1070	1167
1800			1307		1187		1146	1254
1900			1382		1272		1222	1342
2000			1456		1354		1297	1428
2200					1523			1601
2400					1693			1775
2600					1866			1945
2800					2039			2116
3000								2286

* Molten.

TABLE 5.—BRIGHTNESS* (B) CORRESPONDING TO TRUE TEMPERATURE

T = true absolute temperature, °K; $B = A \times 10^n$. *Examples:* W has a brightness of 0.00012 candle/cm² at 1000°K, of 2.26 at 1700°K, and of 347 candle/cm² at 2600°K. Unit of $B = 1$ candle/cm² = 6.452 candle/in.² = 3.142 lambert.

T	n	B. B.†	W	Mo	Ta	C‡	Nernst§	Pt	Ni	n
		A								
1000	−4	2.5	1.2	1.0		2.0		0.7	0.9	−4
1100	−4	21	10	8.1		17.4		6.2	8.0	−4
1200	−2	1.30	0.6	0.50		1.1		0.43	0.52	−2
1300	−2	6.4	2.9	2.4		5.4		2.04	2.5	−2
1400	−1	2.35	1.1	0.89		1.9	0.5	0.74	0.90	−1
1500	−1	7.22	3.3	2.7	3.2	6.0	2.2	2.4	2.8	−1
1600	−1	20.5	9.2	7.65	9.1	16.2	7.8	6.43		−1
1700	0	5.06	2.26	1.87	2.21	4.05	2.27	1.61		0
1800	0	11.25	5.05	4.13	5.04	8.89	6.0	3.56		0
1900	0	22.9	10.40	8.34	10.35	18.5	14.0	7.5		0
2000	1	4.39	2.00	1.59	2.02	3.44	2.93	1.43		1
2100	1	7.94	3.56	2.86	3.63	6.30	5.70			1
2200	1	13.62	6.13	4.85	6.23	10.69	10.6			1
2300	1	22.47	10.05	7.95	9.45	24.45	20.6			1
2400	2	3.50	1.570	1.23	1.46		3.72			2
2500	2	5.31	2.375	1.86	2.22					
2600	2	7.75	3.470	2.70	3.24					
2700	2	11.30	4.980	3.91	4.57					
2800	2	15.80	6.94	5.40	6.16					
2900	2	21.60	9.49							
3000	2	28.90	12.57							
3100	2	37.60	16.47							
3200	2	48.50	21.10							
3300	2	61.10	26.85							
3400	3	7.42	3.37							
3500	3	8.82	4.22							
3600	3	10.30	5.74							

* Computed from brightness of black-body (6) and data in Table 2.
† Black-body (6); data for T = 1000 to 1600° and 2700 to 3600° are calculated.
‡ Untreated carbon filament.
§ Nernst glower.

TABLE 6.—BRIGHTNESS* (B) CORRESPONDING TO COLOR TEMPERATURE (T_c)

T_c = absolute color temperature, °K. Unit of B = 1 candle/cm² = 6.452 candle/in.² = 3.142 lambert.

T_c	C†	C‡	Os
	B		
1400	0.20		0.15
1500	0.62		0.43
1600	1.8	1.8	1.15
1700	4.4	4.1	2.60
1800	9.9	8.9	5.7
1900	20.0	17.4	11.0
2000	39.0	32.5	20.5
2100	68	57.5	35.0
2200	117	102	59.0
2300	187	171	93.0
2400			144.0
2500			209
2600			306
2700			427
2800			590

* Computed from brightness of black-body (6) and data of Table 2.
† Untreated carbon filament.
‡ Treated carbon filament, "Gem."

TABLE 7.—TEMPERATURE, BRIGHTNESS AND EFFICIENCY OF SELECTED SOURCES OF ILLUMINATION

T, T_B, T_c = true, brightness, and color temperature, absolute scale, expressed in °K; E = efficiency; B = intrinsic brightness; C = carbon, Os = Osmium, Ta = Tantalum, W = Tungsten; 50-w. = 50 watt; w.p.c. = watt per candle; cp. std. = candle power standard. Unit of B = 1 candle/cm² = 6.452 candle/in.² = 3.142 lambert; of E = 1 lumen/watt.

Source	T	T_B	T_c	E	B	Remarks
Candle: sperm			1 930		1.0	Bright spot
Paraffin			1 925			
Kerosene: flat		1 500	2 055		1.2	Bright spot
Round		1 530	1 920		1.5	Bright spot
Hefner lamp			1 880		0.7	Bright spot
Pentane lamp*			1 920			10 cp. std.
Gas: flame†			2 160			Batswing
			1 875			Candle
Mantle					6.2	Bright spot
Acetylene‡			2 380			Whole flame
		1 660	2 465		6.7	One spot
		1 730	2 360		10.8	Mees burner
Vacuum lamps:						
C, 4 w.p.c.		2 030	2 080	2.5	55	Filament
3.1 w.p.c.		2 065	2 165	3.2	71	Treated
2.5 w.p.c.		2 130	2 195	4.0	78	Gem
50-w.	2 095		2 080	2.5	55	Untreated (5)
50-w.	2 130		2 195	4.0	78	Gem (5)
Vacuum lamps:						
Os, 2 w.p.c.		2 035	2 185	6.3	61	
Ta, 2 w.p.c.		2 000	2 260	6.3	53	
50-w.	2 180		2 260	6.3	53	(5)
W, 10-w.	2 355		2 390	7.7	128	Straight§§ (5)
25-w.	2 450		2 493	9.8	193	Straight§§ (5)
40-w.	2 460		2 504	10.0	206§	Straight§§ (5)
60-w.	2 465		2 509	10.1	211	Straight§§ (5)
W, Bulb frosted on inside (9):						
15-w.	2 470			8.4	2.3	Coiled
25-w.	2 505			9.5	4.1	Coiled
40-w.	2 535			10.0	5.2	Coiled
Gas-filled lamps (5):						
W, 50-w.					408	White mazda‖
50-w.	2 685		2 670	10.0	469	
75-w.	2 735		2 705	11.8	563	White mazda¶
100-w.	2 760		2 740	12.9	605	
200-w.	2 840		2 810	15.2	781	
200-w.	2 860			10.0		"Daylight"
500-w.	2 960			11.2		"Daylight"
750-w.	3 065					Photographic
900-w.	3 290		3 220	27.3	2 660	Special**
1000-w.	2 990		2 980	20.0	1 225	
1000-w.	3 185		3 175	24.2	2 065	Stereopticon
1500-w.	3 105					Photographic
2000-w.	3 020		3 000	21.2	1 350	Mazda††
10 kw.	3 350		3 300	31.0	3 050	Special**
30 kw.	3 350		3 300	31.0	3 050	Special**
Bulb frosted on inside (9):						
50-w.	2 650			10.0	7.8	Coiled
60-w.	2 655			11.1	9.2	Coiled
100-w.	2 765			13.4	12.3	Coiled
Electric arc:						
Solid C		3 385	3 780		9 200	(10)
Cored C		3 075	3 420		4 130	(10)
Graphite (C)		3 735	3 775		17 300	(10)
Hg, 385-w.	(2)	Direct current			2.2	110 volt
430-w.	(2)	Alternating current			2.4	110 volt
500-w.	(2)	Quartz tube			350	100 volt
Clear sky (7)					0.8	Average
Moon (4)					0.25	Bright spot
Sun‡‡ (as observed from surface of earth)					165 000	
(As observed from top of earth's atmosphere)					224 000	

* Color-matched by Bureau of Standards.
† Mixture of coal gas and water gas, heating value *ca.* 600 BTU/ft.³; "batswing" and "candle" refer to the shape of the flame; the candle-shaped flame was about 10 cm high.
‡ For first two lines, the burner was from a "prest-o-lite" automobile headlight, reflector removed; for third line, a Mees burner was used.
§ For frosted bulb, B = 2.5; for "golden mazda" bulb, B = 2.0 (9).
‖ For bulb, B = 1.3.
¶ Filament, sprayed; for bulb, B = 2.1.
** For special illumination.
†† For inside surface of coil, B = 3 000; for frosted bulb, B = 130.
‡‡ Calculated from data of (1).
§§ Straight filament.

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(For a key to the periodicals see end of volume)

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OPTICAL CONSTANTS OF SUBSTANCES WHICH EXHIBIT METALLIC REFLECTION

JOSEPH VALASEK

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INTRODUCTION

When the angle of incidence is not zero, the light reflected from a metal is elliptically polarized unless the incident light is plane polarized either in or perpendicular to the plane of incidence. Since the reflectivity and the ellipticity are very sensitive to changes in the condition of the surface, published values of the optical constants are quite discordant. The values are here classified according to the preparation of the mirror, since this seems to affect the results in many cases. To obtain the dispersion of the optical constants of some materials, it may be necessary to use data from several tables. It should also be observed that the reflectivity may be calculated from the indices of refraction and absorption with the aid of the formula given in the following section. The values in the reflectivity tables may be supplemented in this way, if necessary.

For all substances in which the index of absorption is not zero, both it and the index of refraction vary with the angle of incidence (**27.1, 45.1**).

Optical constants of dyes and vapors of metals, and data in regard to spectra, emissivity, magneto-optics, photoelectricity, photoconductivity, X-rays, and γ-rays are covered by other reports; *see* index.

SYMBOLS AND NUMERICAL RELATIONS

A	$100 \times$ absorption by a thin film; $A = 100 - (R + T)$.
J_0, J_x	Intensity of parallel light at two planes within the substance, the planes being perpendicular to the direction of propagation of the light, and separated by the distance x.
J_i, J_T, J_r	Intensity of the incident, transmitted and reflected light.
k	Index of absorption for normal incidence in the direction of x; $J_x = J_0 e^{-4\pi n k x/\lambda_0}$, x and λ_0 are to be expressed in the same units.
k_θ	Index of absorption for incidence at an angle θ with the normal x; $J_x = J_0 e^{-4\pi n k_\theta x/\lambda_0}$.
n	Index of refraction for normal incidence = ratio of wave or phase velocity of light *in vacuo* (V) to that in the substance (v); $n = V/v = \lambda_0/\lambda$.
n_θ	Index of refraction for angle of incidence θ; $n_\theta = \sin\theta/\sin\rho$.
R	$100 \times$ reflectivity; $R = 100 J_r/J_i$.
R_0	Value of R when $\theta = 0$.
$R_\parallel$ [$R_\perp$]	Value of R when incident light is plane polarized with electric vector parallel [perpendicular] to the plane of incidence.
T	$100 \times$ transmissivity of a thin film; $T = 100 J_T/J_i$.
$u_\parallel$ [$u_\perp$]	Component of amplitude of reflected light with electric vector $\parallel$ [$\perp$] plane of incidence.
Δ	Difference in phase of $u_\parallel$ and $u_\perp$.
λ	Wave-length in metal of refracted light.
λ_0	Wave-length *in vacuo* of incident light.
ρ	Angle of refraction; $\rho = \sin^{-1}(n_\theta^{-1} \sin\theta)$.
θ	Angle of incidence.
$\bar{\theta}$	Principal angle of incidence = value of θ at which $\Delta = 90°$.
ψ	Azimuth of restored plane of polarization, measured from plane of incidence; $\tan\psi = u_\parallel/u_\perp$.
$\bar{\psi}$	Principal azimuth = value of ψ when $\theta = \bar{\theta}$, *i.e.*, when $\Delta = 90°$.

For transparent metal films, *see* (**8, 17**); for massive metals and opaque films the following relations apply (**10, 61**):

$$\tan\Delta = \sin Q \tan 2P$$
$$\cos 2\psi = \cos Q \sin 2P$$

where

$$\tan P = \frac{[n^4(1+k^2)^2 - 2n^2(1-k^2)\sin^2\theta + \sin^4\theta]^{\frac{1}{2}}}{\sin\theta\tan\theta}$$
$$= (n\sqrt{1+k^2})/\sin\theta\tan\theta, \text{ approximately;}$$
$$\tan 2Q = \frac{2n^2k}{n^2(1-k^2) - \sin^2\theta}$$
$$\tan Q = k, \text{ approximately.}$$
$$R_0 = 100\,\frac{n^2(1+k^2) - 2n + 1}{n^2(1+k^2) + 2n + 1}$$
$$R_\perp = 100\,\frac{(m_\theta - \cos\theta)^2 + m_\theta^2 k_\theta^2}{(m_\theta + \cos\theta)^2 + m_\theta^2 k_\theta^2}$$
$$\frac{R_\parallel}{R_\perp} = \frac{(m_\theta - \sin\theta\tan\theta)^2 + m_\theta^2 k_\theta^2}{(m_\theta + \sin\theta\tan\theta)^2 + m_\theta^2 k_\theta^2}$$

where

$$m_\theta = n_\theta \cos\rho$$
$$2m_\theta^2 = \sqrt{(n^2 - n^2k^2 - \sin^2\theta)^2 + 4n^4k^2} + (n^2 - n^2k^2 - \sin^2\theta)$$
$$2m_\theta^2 k_\theta^2 = \sqrt{(n^2 - n^2k^2 - \sin^2\theta)^2 + 4n^4k^2} - (n^2 - n^2k^2 - \sin^2\theta)$$

$$\sin\bar{\theta}\tan\bar{\theta} = n\sqrt{(1+k^2)}\left[1 - \frac{1}{2}\left(\frac{1-k^2}{1+k^2}\right)\frac{\sin^2\bar{\theta}}{n^2(1+k^2)} + \frac{1}{8}\left(2 - 3\left(\frac{1-k^2}{1+k^2}\right)^2\right)\frac{\sin^4\bar{\theta}}{n^4(1+k^2)^2} - \ldots\right] = n\sqrt{(1+k^2)},$$

approximately;

$$\tan 2\bar{\psi} = k\left[1 + \frac{\sin^2\bar{\theta}}{n^2(1+k^2)} + \left(\frac{1}{1+k^2}\right)\frac{\sin^4\bar{\theta}}{n^4(1+k^2)^2} + \ldots\right] = k, \text{ approximately.}$$

TABLE 1.—REFRACTION AND ABSORPTION OF PURE MASSIVE METALS, I, Mn, MoS_2 AND STEEL

$J_x = J_0 e^{-4\pi nkx/\lambda_0}$; x and λ_0 expressed in same unit. Unit of $\lambda = 1\mu = 10^4 Å = 10^{-4}$ cm.

Ag (34)

λ	n	k
0.226	1.41	0.75
.231	1.43	0.78
.250	1.49	0.92
.257	1.53	0.84
.293	1.57	0.62
.298	1.56	0.58
.322	0.83	0.49
.332	.40	1.61
.336	.26	3.21
.346	.22	5.01
.361	.20	7.22
.395	.16	12.3
.450	.16	14.5
.500	.17	17.1
.550	.18	18.8
.589	.18	20.6
.589	.20*	17.1*
.630	.20†	19.5†

* (39). † (9).

Al (45)

0.431	0.78	2.85
.486	0.93	3.15
.527	1.10	3.39
.589	1.28	3.66
.589	1.44*	3.64*
.657	1.48	3.92

* (30).

Au (53); *cf.* (31, 50, 61)

0.400	1.58	1.13
.420	1.57	1.15
.440	1.54	1.17
.460	1.45	1.20
.480	1.28	1.32
.500	0.94	1.87
.520	.67	2.99
.540	.54	4.32
.580	.42	6.65
.620	.35	8.95
.660	.32	11.20
.700	.28	13.60

Bi (31); *cf.* (1)

0.257	0.99	1.01
.275	0.99	1.15
.298	0.97	1.37
.326	0.98	1.52
.361	1.09	1.64
.398	1.26	1.66
.436	1.80 *l**	1.79 *l**
.441	1.38	1.64
.468	1.47	1.64
.508	1.55	1.64
.546	2.35 *l**	1.63 *l**
.579	2.48 *l**	1.60 *l**
.589	1.78	1.57
.668	1.96	1.58

* (27); *l* = liquid Bi.

C, Graphite (47); *cf.* (19, 57, 62)

λ	n	k
0.436	1.90	0.36
.492	1.94	.34
.546	1.96	.34
.578	1.97	.33
.623	2.00	.33

Cb (57)

0.578	1.80	1.17

Cd (9)

0.436	0.39 *l**	9.13 *l**
.546	0.76 *l**	6.41 *l**
.579	0.82 *l**	6.27 *l**
.589	1.13	4.43
.630	1.31	4.05

* (27); *l* = liquid Cd.

Co (34, 53); *cf.* (9)

0.231	1.10*	1.30*
.257	1.25*	1.45*
.275	1.41*	1.52*
.298	1.50*	1.56*
.347	1.54*	1.61*
.395	1.63*	1.79*
.420	1.68	1.83
.440	1.71	1.87
.480	1.86	1.84
.520	1.98	1.83
.560	2.09	1.83
.600	2.21	1.83
.640	2.34	1.82
.680	2.50	1.78

* (34).

Cr (14); *cf.* (57)

0.257	1.64	2.25
.275	1.27	2.45
.298	1.21	2.23
.325	1.26	2.31
.340	1.26	2.35
.347	1.42	2.12
.361	1.53	2.10
.398	1.72	2.13
.415	1.90	2.13
.444	2.36	1.88
.468	2.47	1.88
.480	2.65	1.79
.502	2.93	1.56
.508	3.06	1.53
.533	3.45	1.41
.588	3.59	1.26
.608	3.28	1.31

Cs, Cs-glass mirror (37)

0.455	0.362	2.37
.489	.339	2.70
.540	.326	3.41
.589	.321	3.70
.641	.326	4.01
.680	.350	4.34

Cu (34, 53); *cf.* (9, 39, 48, 50)

λ	n	k
0.231	1.39*	1.05*
.257	1.40*	1.01*
.275	1.37*	1.01*
.298	1.26*	1.05*
.347	1.19*	1.23*
.395	1.17*	1.50*
.450	1.13*	1.90*
.460	1.19	1.93
.480	1.17	2.00
.500	1.17	2.03
.520	1.15	2.11
.540	1.07	2.25
.560	0.855	2.83
.580	.600	4.66
.589	.62†	4.1†
.589	.64‡	4.08‡
.600	.565	5.51
.620	.580	5.72
.640	.615	5.82
.660	.655	5.77

* (34). † (39). ‡ (30).

Fe (9, 30, 50)

0.589	2.36	1.36
.589	2.18*	1.25*
.589	2.41†	1.41†
.589	2.36†	1.36†

* (50). † (30).

Steel (34, 51, 53)

99 Fe + 1 C

0.227	1.30	1.26
.231	1.32	1.28
.257	1.38	1.35
.298	1.40	1.43
.326	1.37	1.53
.361	1.52	1.63
.400	1.68	1.62
.420	1.79*	1.58*
.440	1.86*	1.55*
.460	1.93†	1.54†
.480	2.07*	1.46*
.500	2.13†	1.46†
.520	2.26*	1.38*
.540	2.30†	1.41†
.580	2.44†	1.36†
.620	2.54†	1.34†
.660	2.64†	1.31†
.700	2.70†	1.31†

* (53). † (51).

Hg, Liquid (12, 31, 38)

0.257	0.61*	2.94*
.275	0.62*	3.03*
.298	0.65*	3.10*
.302	0.55†	4.09†
.313	0.44†	5.75†
.325	0.69*	3.35*
.326	0.68	3.32
.361	0.77	3.51
.365	0.64†	4.64†
.398	0.92	3.44
.405	0.79†	4.30†
.436	0.88†	3.94†

Hg.—(*Continued*)

λ	n	k
0.441	1.01	3.39
.468	1.15	3.21
.508	1.31	2.99
.589	1.62	2.71
.630	1.72	2.73

* (12). † (38).

I (31)

0.326	1.70	0.49
.361	2.04	.65
.398	2.36	.63
.441	2.81	.54
.468	3.08	.47
.508	3.31	.37
.589	3.34	.17

Ir (57)

0.578	2.13	2.28
.660	2.40	2.10

K (11, 35)

0.472	0.070	14.3
.546	.060*	21.5*
.589	.068	22.1
.665	.066	26.8

* (35).

Mg (9)

0.589	0.37	11.8
.63	.40	11.5
Crystal axis* ⊥ (20)		
0.416	0.260	5.95
.440	.290	6.10
.496	.285	6.37
.520	.335	6.97
.560	.337	6.38
.589	.340	6.25
.620	.315	6.97
.650	.323	6.94
Crystal axis* ∥ (20)		
0.416	0.305	4.94
.440	.340	3.87
.496	.365	5.06
.520	.385	5.57
.560	.420	4.62
.589	.390	5.05
.620	.420	5.48
.650	.423	5.18

* Principal axis ⊥ [∥] to plane of incidence.

Mn (14, 30, 57)

0.257	0.661	1.79
.274	0.762	1.67
.297	1.01	1.58
.325	1.03	1.71
.340	1.02	1.75
.347	1.10	1.76
.360	1.16	1.79
.397	1.29	1.83
.414	1.39	1.80
.439	1.54	1.79
.468	1.65	1.71
.479	1.69	1.75
.507	1.84	1.78
.532	1.85	1.77
.578	2.49*	1.56*

Mn.—(*Continued*)

λ	*n*	*k*
0.588	2.25	1.67
.589	2.41†	1.61†
.625	2.23	1.74
.668	2.62	1.55

* (57). † (30).

MoS_2, Molybdenite (32)

0.330	2.22	1.00
.350	2.64	0.98
.370	3.21	.96
.390	3.85	.89
.410	4.00	.81
.430	4.50	.66
.450	4.68	.58
.470	5.00	.47
.500	5.67	.34

Na (11, 35)

0.435	0.058	31.7
.472	.057	33.3
.546	.052	42.6
.546	.047*	47.3*
.589	.044	55.0
.665	.051	55.0

* (35).

Nb; *see* Cb

Ni (9, 50, 53)

0.420	1.42	1.79
.460	1.46	1.89
.500	1.54	1.93
.540	1.63	1.97
.580	1.73	1.98
.588	1.58*	2.06*
.589	1.79†	1.86†
.620	1.82	1.99
.660	1.95	1.98
.700	2.03	1.97

* (50). † (9).

Pb (9, 27); *cf.* (1)

0.436	1.63 *l**	2.28 *l**
.546	2.42 *l**	1.84 *l**
.579	2.56 *l**	1.77 *l**
.589	2.01	1.73
.630	1.97	1.74

* (27); *l* = liquid Pb.

Pd (57)

0.578	1.62	2.10

Pt (9, 39, 62)

0.439	1.63	2.08
.466	1.71	2.11
.477	1.72	2.14
.488	1.76	2.11
.503	1.79	2.15
.517	1.85	2.12
.589	2.07	2.12
.589	2.06*	2.06*
.589	2.03†	1.96†
.630	2.16*	2.06*
.633	2.22	2.10
.665	2.34	2.08
.704	2.43	2.11

* (9). † (39).

Rb (36)

	n	*k*
0.455	0.137	5.28
.489	.134	6.49
.540	.140	7.97
.589	.131	9.28
.641	.140	10.51

Rh (57)

0.578	1.54	3.00
.660	1.81	2.94

Sb (9)

0.589	3.04	1.63
.630	3.17	1.56

Se (21, 31)

0.257	1.73	0.725
.275	1.82	.736
.298	2.46	.635
.326	2.75	.546
.361	2.65	.518
.398	2.88	.426
.441	2.93	.359
.468	2.94	.320
.508	2.92	.281
.589	2.85	.221
.589	3.2*	
.668	2.79	.161
Crystal axis† ⊥ (33, 49, 58)		
0.30	2.2	0.7
.35	2.6	.6
.40	2.9	.6
.45	3.1	.5
.50	3.2	.4
.55	3.3	.3
.60	3.4	.3
.65	3.4	.3
.70	3.5	.3
Crystal axis† ‖ (33, 49, 58)		
0.30	3.4	0.7
.35	3.6	.6
.40	4.0	.6
.45	4.2	.5
.50	4.3	.4
.55	4.3	.3
.60	4.4	.3
.65	4.5	.3
.70	4.5	.3

* (21). † Principal axis ⊥ [‖] to plane of incidence.

Si (26, 30, 57)

0.578	3.87	0.12
0.589	4.24*	.114*
1.00 to 2.25	4.07†	.095†

* (30). † (26).

Sn (9, 12, 27); *cf.* (1)

0.257	1.12	2.98
.275	1.12	2.95
.298	1.04	2.66
.325	0.98	2.45
.347	1.01	2.20
.361	0.91	2.13
.398	0.68	2.82
.425	0.70	3.55

Sn.—(*Continued*)

λ	*n*	*k*
0.436	1.18 *l**	3.44 *l**
.447	0.72	4.03
.468	0.70	4.44
.480	0.71	4.68
.502	0.78	4.58
.533	0.89	4.41
.546	1.73 *l**	3.08 *l**
.579	1.77 *l**	3.09 *l**
.588	1.12	4.03
.589	1.48†	3.55†
.620	1.25	3.83
.630	1.66†	3.30†
.668	1.42	3.53

* Liquid (27); *cf.* (1). † (9).

Ta (57)

0.578	2.05	1.13

Te (33)

Crystal axis† ‖		
0.300	1.5	0.1
.350	2.0	.2
.400	2.4	.2
.450	2.5	.3
.500	2.6	.4
.550	2.7	.5
.600	2.5	.6
.650	2.0	.5
Crystal axis† ⊥		
0.300	1.9	0.3
.400	2.4	.3
.450	2.9	.4
.500	3.0	.5
.550	3.1	.6
.600	2.9	.6
.650	2.4	.6

V (57)

λ	*n*	*k*
0.578	3.03	1.16

W (57)

0.578	2.76	0.98

Zn (9, 31)

0.257	0.55	1.10
.275	0.46	2.56
.298	0.47	3.41
.326	0.60	3.72
.361	0.72	3.63
.398	0.85	3.45
.441	0.93	3.40
.468	1.05	3.32
.508	1.41	2.92
.589	1.93	2.41
.589	2.12(9)	2.60(9)
.630	2.36	2.34
.668	2.62	1.94
Crystal axis† ⊥ (20)		
0.455	1.00	3.55
.486	1.35	3.14
.520	1.47	2.94
.560	1.92	2.60
.589	2.58	2.29
.630	2.47	2.47
.650	2.47	2.15
Crystal axis† ‖ (20)		
0.455	0.78	4.58
.486	1.09	3.80
.520	1.32	3.49
.560	1.61	3.08
.589	2.02	2.86
.630	2.27	2.79
.650	2.07	2.60

† Principal axis ⊥ [‖] to plane of incidence.

Table 2.—Refraction and Absorption of Alloys

Grouped according to number of components; in each group the arrangement is alphabetical by chemical symbols. At. %, V %, Wt. % = atomic %, volume %, weight %; C = composition. $J_x = J_0 e^{-4\pi nkz/\lambda_0}$; x and λ_0 expressed in same unit. Unit of λ = $1\mu = 10^4 Å = 10^{-4}$ cm.

Ag-Cu (39)

λ = 0.589, C = Wt. % Cu

C	*n*	*k*
0	0.20	17.1
3	.25	11.4
6	.52	6.5
10	.49	7.5
30	.36	6.6
50	.31	7.6
72	.24	13.8
80	.42	7.1
90	.51	5.7
95	.64	5.0
100	.62	4.1

Ag-Cu (31)

C = 50 Wt. % Cu

λ	*n*	*k*
0.257	0.86	0.94
.275	.89	0.88
.298	.85	1.05
.326	.72	1.40

Ag-Cu.—(*Continued*)

λ	*n*	*k*
0.361	0.63	1.82
.398	.59	2.20
.441	.60	3.26
.468	.58	3.83
.508	.58	3.64
.589	.37	6.68
.668	.32	9.38

Ag-Pt (39)

λ = 0.589, C = Wt. % Pt

C	*n*	*k*
0	0.20	17.1
15	0.71	5.92
30	1.15	3.69
40	1.13	2.74
45	1.26	2.42
50	1.57	2.15
90	2.12	1.85
100	2.03	1.96

Ag-Sn [2]
$\lambda = 0.578$, C = Wt. % Sn

C	n	k
4	1.05	3.79

Ag-Tl [2]
$\lambda = 0.578$, C = Wt. % Tl

2.73	0.332	12.16
4.76	0.423	10.14

Al-Cu [30]
$\lambda = 0.589$, C = V % Al

0	0.64	4.08
19	0.80	3.70
36.4	1.32	2.56
51.4	1.97	1.62
57.8	2.24	1.58
76	1.68	2.35
100	1.44	3.64

Bi-Hg, Liquid [27]
$\lambda = 0.436$, C = At. % Hg

0	1.80	1.79
40	1.59	2.07
100	1.01*	3.39*
$\lambda = 0.546$		
0	2.35	1.63
40	2.24	1.78
100	1.48	2.81*
$\lambda = 0.579$		
0	2.48	1.60
40	2.38	1.68
100	1.62	2.80*

* [31].

Bi-Pb, Liquid [27]
$\lambda = 0.436$, C = At. % Pb

0	1.80	1.79
6	1.85	1.70
18	1.82	1.77
26.4	1.73	1.90
48	1.74	1.95
61	1.74	1.98
75	1.78	1.99
86	1.63	2.28
100	1.63	2.28
$\lambda = 0.546$		
0	2.35	1.63
6	2.35	1.64
19	2.44	1.68
26.4	2.44	1.68
48	2.24	1.77
61	2.34	1.79
75	2.32	1.84
86	2.42	1.84
100	2.42	1.84
$\lambda = 0.579$		
0	2.48	1.60
6	2.52	1.59
19	2.48	1.63
26.4	2.56	1.64
48	2.56	1.64
60	2.55	1.67
75	2.62	1.67
86	2.56	1.77
100	2.56	1.77

C-Fe, Steel; *see* Fe, Table 1

Cd-Hg [2]
$\lambda = 0.578$, C = Wt. % Hg

C	n	k
5.14	1.69	2.75
10	0.79	6.08

Cd-Pb, Liquid [27]
$\lambda = 0.436$, C = At. % Pb

0	0.39	9.13
12	0.55	6.53
22	0.81	4.61
33.5	1.02	3.74
64	1.27	2.88
79.5	1.52	2.37
100	1.63	2.28
$\lambda = 0.546$		
0	0.76	6.41
12	1.14	4.20
22	1.14	4.20
33.5	1.58	3.07
64	1.92	2.32
79.5	2.05	2.16
100	2.42	1.84
$\lambda = 0.579$		
0	0.82	6.27
12	1.43	3.51
22	1.43	3.51
33.5	1.69	2.98
64	1.99	2.40
79.5	2.21	2.05
100	2.56	1.77

Cu-Fe [30]
$\lambda = 0.589$, C = V % Fe

0	0.64	4.08
27.6	1.77	1.53
53.4	2.24	1.32
77.6	2.62	1.30
100	2.41	1.41

Cu-Ni [30]; *cf.* [2, 9]
$\lambda = 0.589$, C = V % Ni

0	0.64	4.08
25	1.61	2.15
40	2.09	1.47
50	2.33	1.55
60	2.12	1.55
75	2.01	1.57
100	1.79	1.85

Cu-Sn, C = Wt. % Sn

$\lambda = 0.578$ [2]		
5	0.63	6.66
$\lambda = 0.55$ [56]		
32	1.19	2.4
$\lambda = 0.60$ [56]		
32	1.22	2.7

Cu-Zn [2]
$\lambda = 0.578$, C = Wt. % Zn

3.11	0.50	8.39
5.0	0.45	9.57

Fe-Mn [30]
$\lambda = 0.589$, C = V % Mn

0	2.36	1.36
50	2.42	1.53
75	2.43	1.55
100	2.41	1.61

Fe-Ni [30]
$\lambda = 0.589$, C = V % Ni

C	n	k
0	2.41	1.41
1.7	2.44	1.41
6.2	2.38	1.40
20.0	2.31	1.47
22.8	2.30	1.48
25.8	2.25	1.52
33	2.23	1.50
44.2	2.16	1.63
73	2.01	1.74
100	1.79	1.86

K-Na [35]
$\lambda = 0.546$, C = Wt. % Na

0.0	0.060	21.5
15.7	0.088	17.6
25.8	0.124	12.8
34.0	0.137	12.5
45.0	0.115	15.6
55.0	0.108	16.8
63.8	0.100	18.5
82.7	0.081	27.2
100.0	0.047	47.3

Ni-Si [30]
$\lambda = 0.589$, C = V % Si

0	1.79	1.85
16.3	2.04	1.56
29.1	2.35	1.32
39.3	2.61	1.12
47.4	2.87	0.99
100	4.24	0.114

Pb-Sn, Liquid [27]
$\lambda = 0.436$, C = At. % Sn

0	1.63	2.28
14.5	1.46	2.61
62.5	1.24	3.09
93	1.25	3.18
100	1.18	3.44

Pb-Sn.—(*Continued*)

C	n	k
$\lambda = 0.546$		
0	2.42	1.84
14.5	2.00	2.30
62.5	1.91	2.52
93	1.70	3.05
100	1.73	3.08
$\lambda = 0.579$		
0	2.56	1.77
14.5	2.24	2.14
62.5	2.03	2.50
93	1.89	2.81
100	1.77	3.09

Pt-Rh [57]
$\lambda = 0.578$, C = Wt. % Rh

10.0	1.79	2.35
$\lambda = 0.660$		
10.0	2.08	2.22

Wood's metal [9, 31]; *cf.* [1]; C = Wt. % 50Bi + 25Pb + 12.5Sn + 12.5Cd.

λ	n	k
0.257	0.58	2.68
.275	0.68	2.73
.298	0.76	2.86
.326	0.85	2.81
.361	0.96	2.80
.398	1.14	2.69
.441	1.22	2.67
.468	1.28	2.46
.508	1.53	2.36
.589	1.80	2.24
.589	2.03*	2.29*
.589	2.10 *l**	2.15 *l**
.668	2.04	2.10

* [9]; *l* = liquid.

Table 3.—Refraction and Absorption by Opaque Films of Pure Metals

Cath, Chem, Elec = film deposited by cathode sputtering, by chemical reaction, by electrolysis. $J_x = J_0 e^{-4\pi nkz/\lambda_0}$; x and λ_0 expressed in same unit. Unit of $\lambda = 1\mu = 10^4$Å $= 10^{-4}$ cm.

Ag, Cath [28]; *cf.* [16, 17, 43]

λ	n	k
0.546	0.168	19.6
0.578	0.172	19.3
Chem [13, 51]		
0.460	0.270*	12.0*
0.500	0.273*	13.0*
0.540	0.279*	14.0*
0.580	0.284*	14.8*
0.620	0.291*	15.5*
0.650	0.19	18.1
0.660	0.299*	16.3
0.700	0.308*	16.9*
0.750	0.16	28.6
0.940	0.15	36.2
1.15	0.23	31.2
1.47	0.36	23.9
2.10	1.00	14.3
2.89	1.39	13.7

Ag, Chem.—(*Continued*)

λ	n	k
3.38	2.06	11.1
4.04	2.98	9.5
4.37	4.34	7.4
Chem [51], on glass, light incident through the glass		
0.460	0.339	6.90
.500	.343	7.72
.540	.348	8.51
.580	.356	9.26
.620	.365	9.93
.660	.375	10.46
.700	.386	10.96

* [51].

Au, Cath [28]

0.546	0.45	5.36
0.578	0.30	8.93

Au.—(*Continued*)

λ	*n*	*k*
Elec (13, 31, 51)		
0.257	0.92*	1.24*
0.275	1.06*	1.20*
0.298	1.10*	1.25*
0.326	1.26*	1.29*
0.361	1.30*	1.35*
0.398	1.29*	1.41*
0.441	1.18*	1.57*
0.460	1.66	1.10
0.468	1.10*	1.66*
0.480	1.53	1.22
0.500	1.33	1.51
0.520	1.10	1.98
0.540	0.94	2.72
0.560	0.81	3.50
0.580	0.73	4.14
0.600	0.67	4.86
0.620	0.65	5.29
0.640	0.63	5.69
0.660	0.64	5.86
0.670	0.28†	18.0†
0.680	0.62	6.26
0.870	0.21†	26.0†
1.07	0.25†	28.6†
1.41	0.36†	26.0†
1.69	0.40†	28.6†
2.11	0.50†	28.6†
2.87	0.73†	22.0†
3.14	0.80†	23.6†
3.50	0.96†	23.6†
4.13	1.60†	18.0†
4.83	1.83†	18.0†

* (31). † (13).

Cu, Cath (13, 28, 43, 46)

0.546	0.901*	2.70*
0.546	0.925†	2.09†
0.546	0.97‡	2.76‡
0.578	0.515*	4.91*
0.578	0.501†	3.98†
0.810	0.43	9.8
1.03	0.43	13.0
1.27	0.37	19.1
1.53	0.53	15.1
1.77	0.73	13.0
2.28	0.68	16.8
3.05	0.90	15.9
3.25	1.08	15.1
3.59	1.39	13.6
4.20	1.92	11.9
Elec (13, 51)		
0.460	1.57	1.44
0.480	1.53	1.50
0.500	1.50	1.58
0.520	1.43	1.68
0.540	1.38	1.79
0.560	1.27	2.02
0.580	1.07	2.66
0.600	0.98	3.25
0.640	0.96	3.68
0.660	1.00	3.72
0.700	1.03	3.69
0.740	1.25§	3.6§
0.900	1.93§	2.6§

Cu, Elec.—(*Continued*)

λ	*n*	*k*
1.10	3.09§	2.0§
1.32	4.32§	1.5§
3.11	4.74§	1.7§
3.60	7.12§	1.3§
4.61	7.61§	1.3§

* (28). † (46). ‡ (43). § (13).

Fe, Cath (31)

0.257	1.01	0.874
.275	0.95	0.841
.298	0.92	0.903
.326	0.99	0.923
.361	1.04	1.05
.398	1.17	1.11
.441	1.28	1.07
.468	1.34	1.03
.508	1.38	1.08
.589	1.51	1.08
.668	1.70	1.08

Ir, Cath (13); *cf.* (43)

0.860	3.28	1.63
1.16	4.26	1.61
1.57	5.16	1.54
2.77	6.55	1.43
3.36	8.80	1.28
4.60	12.28	1.19

Ni, Cath (28, 31)

0.257	1.09	1.10
.275	1.09	1.06
.298	1.09	1.04
.326	1.08	1.00
.361	1.08	1.01
.398	1.09	1.08
.441	1.16	1.06
.468	1.17	1.17
.508	1.19	1.29
.546	1.81*	1.57*
.578	1.84*	1.61*
.589	1.30	1.52
.668	1.35	1.61
Elec (31)		
0.257	0.87	1.42
.275	1.12	1.46
.298	1.31	1.39
.326	1.32	1.41
.361	1.28	1.47
.398	1.37	1.70
.441	1.46	1.85
.468	1.44	2.00
.508	1.50	2.06
.589	1.58	2.16
.668	1.74	2.18

* (28).

Pt, Cath (13, 28); *cf.* (29, 44)

0.546	1.83*	2.09*
0.578	1.92*	2.10*
1.00	3.42	1.83
1.52	4.71	1.76
1.97	5.92	1.65
3.29	7.50	1.62
3.41	8.82	1.56
4.65	10.9	1.41

Pt.—(*Continued*)

λ	*n*	*k*
Elec (31)		
0.257	1.17	1.41
.275	1.29	1.51
.298	1.28	1.67
.326	1.28	1.72
.361	1.38	1.77
.398	1.74	1.71
.441	1.94	1.63

Pt, Elec.—(*Continued*)

λ	*n*	*k*
0.468	2.09	1.57
.508	2.29	1.48
.589	2.63	1.35
.668	2.91	1.26

* (28).

W, Cath (30); *cf.* (42)

0.579	2.8	
0.589	3.5	

Table 4.—Refraction and Absorption of Transparent Films of Pure Metals

Films are deposited by cathode sputtering. τ = thickness; $J_x = J_0 e^{-4\pi nkx/\lambda_0}$; x and λ_0 expressed in same units. Unit of τ = 1mμ = $10^{-3}\mu$ = 10^{-7} cm; of λ = 1μ = 10^4Å = 10^{-4} cm.

Ag (16), λ = 0.436

τ	*n*	*k*
0.9	2.27	0.58
2.4	1.56	0.68
2.8	1.34	1.38
28.6	0.58	3.71
53.2	0.71	2.92
λ = 0.546		
0.6	4.50	0.067
0.9	4.25	0.45
2.4	3.23	0.45
2.8	2.53	0.78
5.5	2.07	0.83
28.6	1.22	2.25
53.2	0.81	3.23
96.2	0.21	14.9
λ = 0.579		
53.2	0.90	3.19
λ = 0.622		
0.9	4.83	0.46
2.8	2.90	0.68

Au (44), λ = 0.500

1.0	1.96	0.46
1.5	1.59	0.85
3.4	1.34	1.22
9.2	1.12	1.62
23.1	1.02	1.80
32.2	1.06	1.69
50.3	1.06	1.64
72.6	1.09	1.58
113.2	0.85	1.94
λ = 0.600		
1.0	2.09	0.40
1.5	2.25	0.89
3.4	1.63	1.64
9.2	0.77	3.74
23.1	0.66	4.39
32.2	0.73	3.75
50.3	0.77	3.48
72.6	0.77	3.43
113.2	0.35	7.12
λ = 0.700		
1.5	3.31	0.55
3.4	2.14	1.42
9.2	1.13	3.10
23.1	0.58	5.79
32.2	0.63	4.92
50.3	0.63	4.62
113.2	0.20	12.8

Cu (16); *cf.* (3, 43)

τ	*n*	*k*
λ = 0.436		
0.8	3.23	0.15
13.7	1.93	0.47
20.2	1.80	1.10
λ = 0.546		
0.8	1.96	0.41
13.7	1.50	1.50
20.2	1.45	1.64
37.2	1.26	1.91
40.1	1.23	1.95
44.8	1.13	1.95
λ = 0 622		
0.8	0.60	1.43
13.7	0.92	1.62

Pd (44), λ = 0.600

0.2	3.10	0.58
0.4	3.40	0.20
1.7	2.94	0.57
3.1	2.84	0.65
5.1	2.60	0.82
6.4	2.46	0.89
9.6	2.20	1.05
22.0	2.10	1.24
33.1	2.01	1.41
39.7	1.65	1.60
56.3	1.70	1.76
71.1	1.86	1.56
89.7	1.72	1.66
111.5	1.95	1.39
τ = 232mμ		
λ	*n*	*k*
0.500	1.74	1.24
0.550	1.76	1.36
0.600	1.92	1.31
0.650	1.94	1.41
0.700	2.05	1.40

Pt (44), λ = 0.600

τ	*n*	*k*
1.4	3.45	0.29
2.6	3.17	0.74
4.9	2.65	1.09
7.0	2.25	1.30
11.7	2.16	1.39
16.8	2.10	1.44
26.0	2.04	1.47

TABLE 5.—REFLECTIVITY OF PURE METALS AND STEEL: NORMAL INCIDENCE ON MASSIVE METAL

$R_0/100 = J_r/J_i$. For qualitative comparison with speculum metal for $\lambda = 0.103$ to 0.160μ, *see* Gardner [18] for Ag, Al, Au, Cu, Steel, Pt, and Si, and Hulburt [25] for Ni. Unit of $\lambda = 1\mu = 10^4$Å $= 10^{-4}$ cm.

Ag [7, 22]

λ	R_0
0.45	88.0*
0.50	90.0*
0.55	91.5*
0.60	92.7*
0.65	93.5*
0.70	94.1*
0.80	95.1*
0.90	96.0*
1.00	96.4
1.50	97.3
2.00	97.3
3.00	97.3
4.00	97.7
5.00	97.3
7.00	98.5
9.00	98.9
11.00	99.0
14.0	98.8

* [7].

Al [5]; *cf.* [9]

1.06	73.8
1.71	80.8
3.06	88.3
3.96	91.4
5.24	93.8
6.75	95.2
8.02	96.9
9.38	97.4
10.49	96.9
12.03	97.3

Au, Full radiation* [4]

t*	R
500	97.7
1000	97.6
1500	97.5
2000	96.8
2500	95.7
3000	93.7
3500	91.0
4000	87.6

Polarized light† [61]

$\lambda = 0.620$

θ	$R_\perp$
0	88.0
20	88.4
40	91.2
60	94.2
70	97.2
80	98.7
85	97.8
θ	$R_\parallel$
0	88.3
20	87.7

Au, Polarized light† (*Continued*)

θ	$R_\parallel$
40	86.2
60	81.5
70	80.4
80	82.8
85	90.1
θ =	60°
λ	$R_\perp$
0.500	68.3
0.540	83.2
0.580	90.8
0.660	94.3
λ	$R_\parallel$
0.500	33.2
0.540	59.5
0.580	74.3
0.660	84.8

* From black-body at temperature t, °C.

† $R_\perp [R_\parallel] = R$ when electric vector is $\perp$ [$\parallel$] to plane of incidence; θ = angle of incidence.

Bi [22]; *cf.* [9]

λ	R_0
3.00	71.7
4.00	75.2
5.00	77.2
7.00	79.5
9.00	81.4
11.00	83.2
14.00	81.6

C, Graphite [6, 25]; *cf.* [19, 57, 62]

0.20	18*
0.25	19*
0.30	19*
0.35	19*
0.40	21
0.50	22.5
0.60	23.5
0.70	24.0
0.80	25.0
1.00	26.8
1.20	28.3
1.40	30.0
1.60	32.0
2.00	35.2
2.50	39.5
3.00	43.0
3.50	46.0
4.00	47.5
5.00	50.5
6.00	52.0
7.00	53.5
8.00	55.5
9.00	57.5
10.00	59.0

* [25].

Cd [5]

λ	R_0
1.06	70.8
1.71	85.0
3.06	93.0
5.24	95.9
6.75	97.0
9.38	98.4
12.03	98.2

Co [5, 25]

0.188	33*
0.200	37*
0.251	44*
0.305	51*
0.357	54*
1.06	67.5
1.71	71.5
3.06	76.7
3.96	80.7
5.24	86.2
6.75	92.7
8.02	94.8
9.38	96.4
10.49	96.8
12.03	96.6

* [25].

Cr [6, 25]

0.188	33*
0.200	36*
0.251	32*
0.305	37*
0.357	41*
0.50	55
0.70	56
1.00	57
1.40	59
1.60	61
2.00	63
2.50	66
3.00	70
4.00	76
5.00	81
6.00	85
8.00	89
9.00	92
10.00	93

* [25].

Cs, Cs-glass mirror [37]

0.455	37.2
0.489	45.7
0.540	54.1
0.589	58.6
0.641	62.9
0.680	63.2

Cu [22]; *cf.* [9, 39, 48, 50]

λ	R_0
0.251	25.9
0.288	24.3
0.305	25.3
0.326	24.9
0.357	27.3
0.385	28.6
0.420	32.7
0.450	37.0
0.500	43.7
0.550	47.7
0.600	71.8
0.650	80.0
0.700	83.4
0.800	88.6
1.00	90.1
1.50	93.8
2.00	95.5
3.00	97.1
4.00	97.3
5.00	97.9
7.00	98.3
9.00	98.4
11.00	98.4
14.00	97.9

Fe [5]

0.50	55.0
0.60	57.5
0.70	59.5
0.80	61.5
1.00	65.0
1.40	71.5
2.00	78.0
3.00	84.5
4.00	89.5
5.00	91.5
6.00	93.0
7.00	94.0
8.00	94.0
9.00	93.8

Steel [22, 25, 51]

99 Fe + 1 C

0.188	22*
0.200	27*
0.251	38*
0.305	44*
0.357	50*
0.460	55.5
0.500	56.0
0.540	56.0
0.580	57.3
0.620	57.3
0.660	58.0
0.700	58.0
1.00	63†
2.00	77†
3.00	83†
4.00	88†
9.00	93†
14.00	96†

Steel.—(*Cont'd*)

Polarized light‡ [61]

$\lambda = 0.580$

θ	$R_\perp$
0	55.5
10	55.5
20	57.3
30	59.9
40	63.4
50	68.5
60	74.6
70	81.1
75	86.9
80	89.5
82.5	93.0
θ	$R_\parallel$
0	55.8
10	54.7
20	54.1
30	50.9
40	47.0
50	40.8
60	34.0
70	26.2
75	24.0
80	27.0
82.5	33.8

$\theta = 60°$

λ	$R_\perp$
0.500	73.6
0.540	74.4
0.620	75.4
0.660	75.5
λ	$R_\parallel$
0.500	34.1
0.540	33.7
0.620	34.3
0.660	35.6

* [25].

† [22].

‡ $R_\perp [R_\parallel] = R$ when electric vector is $\perp$ [$\parallel$] to plane of incidence; θ = angle of incidence.

Hg, Glass backed with Hg [22]

λ	R_0
0.450	72.8
0.500	70.9
0.550	71.2
0.600	69.9
0.650	71.5
0.700	72.8

Ir [5]

1.06	79.4
3.06	91.4
5.24	94.2
6.75	94.7
9.38	95.6
12.03	96.1

K [15]

λ	R_0
0.254	10.6
0.265	17.6
0.280	25.2
0.313	33.2
0.334	58.0
0.365	74.0
0.405	79.0
0.436	88.0
0.546	92.5

Mg [6, 25]

0.188	13*
0.200	21*
0.251	32*
0.305	37*
0.357	45*
0.50	72
0.60	73
1.00	74.0
1.40	75.0
2.00	77.0
2.50	79.0
3.00	80.5
4.00	83.5
5.00	86.0
6.00	88.0
7.00	91.0
8.00	93.0
9.00	93.0

* [25].

Mo [6, 25]

0.188	27*
0.200	32*
0.251	24*
0.305	43*
0.357	41*
0.40	44.0
0.46	44.6
0.50	45.5
0.60	47.6
0.70	49.8
0.80	52.3
1.00	58.2
1.20	63.6
1.40	69.0
1.60	74.2
2.00	81.6
2.50	85.5
3.00	87.6
3.50	89.2
4.00	90.5
5.00	92.0
6.00	93.0
8.00	93.7
10.00	94.5
12.00	95.2

* [25].

Na [15]

0.254	78.0
0.265	81.0
0.280	80.0
0.313	78.0
0.334	78.0

Na.—(*Continued*)

λ	R_0
0.365	78.5
0.405	80.5
0.436	87.5
0.546	96.0

Pd (5, 25)

1.06	74.8
1.71	79.3
3.06	87.5
3.96	88.1
5.24	90.4
6.75	93.3
8.02	94.7
9.38	95.3
10.49	96.6
12.03	96.5

Pt (22, 25); *cf.* (6)

0.188	35*
0.200	38*
0.251	42*
0.305	49*
0.357	51*
9.00	95.4
11.00	95.6
14.00	96.4

* (25).

Rh (6)

0.500	76.0
0.800	81.0
1.00	84.0
1.40	88.3
2.00	91.0
3.00	92.0
4.00	92.5
5.00	93.0
7.00	93.5
9.00	94.5

Sb (6)

0.600	53
1.00	55
1.60	58
2.00	60
3.00	65
4.00	68
6.00	70
9.00	72

Si (6)

0.500	34
0.600	32
0.800	29
1.00 to 9.00	28

Sn (5)

1.06	54.0
1.71	59.3
3.06	68.6

Sn.—(*Continued*)

λ	R_0
3.96	71.7
5.24	76.7
6.75	80.3
8.02	83.2
9.38	87.0
10.49	87.0
12.03	86.9

Ta (5, 25)

0.188	13*
0.200	13*
0.251	15*
0.305	29*
0.357	25*
0.50	38
0.60	45.0
0.80	64.5
1.00	78.5
1.20	84.0
1.60	88.0
2.00	90.5
2.50	91.6
3.00	92.3
4.00	93.0
5.00	93.0
7.00	93.5
8.00	93.8
12.00	95.0

* (25).

Te (6, 25)

0.188	21*
0.200	22*
0.251	23*
0.305	32*
0.357	41*
0.60	49
0.80	48
1.00	49.5
1.20	50
1.60	51
2.00	52
3.00	53
4.00	57
6.00	63
8.00	72
9.00	78

* (25).

V (6)

0.50	57.0
0.70	58.5
1.00	61.3
1.40	64.5
2.00	69
3.00	74.3
4.00	78.8

V.—(*Continued*)

λ	R_0
6.00	85
8.00	89.8
9.00	92

W (6, 25, 59)

0.188	14*
0.200	16*
0.251	16*
0.305	25*
0.357	28*
0.40	47.0
0.46	48.2
0.50	49.3
0.60	51.3
0.67	51†
0.80	56.3
0.80	55†
1.00	62.3
1.20	68.2
1.27	70†
1.40	73.8
1.60	78.0
1.90	83†
2.00	84.6
2.50	89.2
2.90	92†
3.00	90.5
3.50	92.0
4.00	92.8
5.00	94.0
6.00	94.6
7.00	95.1
8.00	95.6
9.00	95.5
10.00	95.5
12.00	96.3

* (25). † (59).

Zn (5, 7)

0.45	54.0*
0.50	55.0*
0.55	56.0*
0.60	57.5*
0.70	61.0*
0.80	61.5*
0.90	55.5*
1.00	49.0*
1.20	74.7*
1.40	85.8*
1.75	92.0*
2.00	94.0*
3.06	95.5
5.24	97.2
6.75	97.2
9.38	98.1
12.03	98.3

* (7).

Table 6.—Reflectivity of Alloys

All compositions expressed in weight %; tabular values are R_0; $R_0/100 = J_r/J_i$; unit of $\lambda = 1\mu = 10^4\text{Å} = 10^{-4}$ cm

λ	1	2	3	4	5	6	7	8
0.188					23			
0.200					25			
0.251	25	67.0			29.9		35.8	
0.288	29	70.6			37.7		37.1	
0.305	31	72.2			41.7		37.2	
0.326	33	75.5					39.3	
0.357	37	81.2			51.0		43.3	
0.385	41	83.9			53.1		44.3	
0.420	44	83.3			56.4		47.2	
0.450	46	83.4	63.5		60.0	56.5	49.2	
0.500	48	83.3	65.8		63.2	57.8	49.3	
0.550	52	82.7	68.3		64.0	59.0	48.3	
0.600		83.0	70.1		64.3	60.2	47.5	
0.650		82.1	71.0	70.0	65.4	61.8	49.7	
0.700		83.3	71.8	71.2	66.8	63.7	54.9	
0.800		84.3	73.0			67.2	63.1	71.1
1.00		84.1	74.0	72.4	70.5	72.3	69.8	74.3
1.50		85.5	75.3	77.8	75.0	78.2	79.1	78.1
2.00		86.7	76.8	82.3	80.4	83.8	82.3	87.0
3.00		87.4	80.0	85.6	86.2	88.7	85.8	90.1
4.00		88.7	82.8	88.3	88.5	91.0	87.1	91.9
5.00		89.0		89.5	89.1		87.3	92.6
7.00		90.0		92.7	90.1		88.6	93.6
9.00		90.9		93.0	92.2		90.3	
11.00		90.7		93.4	92.9		90.2	
14.00		92.2		94.2	93.6		90.3	

1. Al-Cu, Duralumin (8); 94.19 Al + 4.20 Cu + 0.37 Fe + 0.51 Mn + 0.54 Mg + 0.19 Si.
2. Al-Mg, Mach's mirror magnalium (22); 69 Al + 31 Mg.
C-Fe Steel; *see* **Fe**, Table 5.
3. Co-Cr, Stellite (7); secret composition.
4. Cu-Ni, Constantan (22); 60 Cu + 40 Ni.
5. Cu-Sn, Speculum metal; Ross's metal (22); 68 Cu + 32 Sn.
6. Cu-Fe-Ni, Monel metal (7); 68 to 70 Ni + 1.5 Fe + 30.5 to 28.5 Cu.
7. Cu-Fe-Ni-Sn, Brandes and Schumann alloy (22); 32 Cu + 34 Sn + 29 Ni + 5 Fe.
8. Cu-Ni-Zn, German silver (41); 52 Cu + 26 Zn + 22 Ni.

Table 7.—Reflectivity of Sulfides Which Show Metallic Reflection (5, 8, 54)

FeS_2 = Pyrites, MoS_2 = Molybdenite, PbS = Galena, Sb_2S_3 = Stibnite; $R_0/100 = J_r/J_i$; unit of $\lambda = 1\mu = 10^4\text{Å} = 10^{-4}$ cm

λ	FeS_2	MoS_2	PbS	Sb_2S_3
0.24	49	53	40	52
0.25	48	57	40	51
0.27	48	56	42	57
0.30	50	50	49	61
0.35	46	48	48	60
0.40	38	50	41	54
0.45	44	53	37	51
0.50	52	47	34	49
0.55	53	42	37†	42*
0.60	54*	42†	36†	41*
0.70	60*	42†	42†	44†
1.0	62†	39†	35†	40†
3.0	62†	39†	31†	37†
6.0	62†		31†	37†
11.0	62†		31†	37†
13.0	62†			30†

* (54). † (5).

TABLE 8.—REFLECTIVITY OF OPAQUE FILMS OF PURE METALS

$R_0/100 = J_r/J_i$; unit of $\lambda = 1\mu = 10^4$Å $= 10^{-4}$ cm

Deposited by cathode sputtering [25]; tabular values $= R_0$

λ	Ag*	Al†	Au	Bi	Cd	Cu*
0.188	22	25	17	17	20	23
0.200	25	31	20	18	23	31
0.251	33	53	25	24	36	26
0.305	17	64	36	30	49	29
0.357	67	70	45	36	60	32

λ	Ni*	Pb	Sb	Si	Sn	Zn
0.188	35	16	31	64	8	17
0.200	44	18	33	73	9	22
0.251	38	20	53	75	17	39
0.305	46	22	64	73	21	48
0.357	49	26	71	60	27	51

* Ag is chemically, and Cu and Ni are electrolytically deposited; *see* below for other data. † *Cf.* [55].

Deposited by cathode sputtering [22]; tabular values $= R_0$

λ	Ag	Au	Pt	λ	Ag	Au	Pt
0.65	94.6	89.1	63.8	7.00	98.3	95.7	93.0
1.00	95.5	93.6	70.4	8.00	98.1	96.1	92.5
1.50		94.8	75.3	9.00	98.1	96.1	92.5
2.00	96.8	94.9	79.8	10.00	98.5	96.4	93.1
3.00	97.4	95.6	88.5	11.00	98.8	96.5	92.7
4.00	97.6	96.0	91.6	12.00	98.1	97.2	94.9
5.00	97.3	95.7	90.8	14.00		96.7	94.7

Chemically (Chem) and electrolytically (Elec) deposited

Ag, Chem [22, 25, 51]

λ	R_0
0.188	22*
0.200	25*
0.251	34.1
0.288	21.2
0.305	9.1
0.316	4.2
0.326	14.6
0.338	55.5
0.357	74.5
0.385	81.4
0.420	86.6
0.450	90.5
0.460	90.5†
0.500	92.7†
0.500	91.3
0.540	93.0†
0.550	92.7
0.580	94.8†
0.600	92.6
0.620	95.0†
0.650	93.5
0.660	95.2†
0.700	94.6
0.700	95.3†
0.800	96.3
1.00	96.6
1.50	97.9
3.00	98.1
4.00	98.5
5.00	98.1
7.00	98.5
14.00	98.8

Ag.—(*Continued*) Chem on glass‡ [51]

λ	R_0
0.460	81.0
0.500	84.0
0.540	86.2
0.580	88.5
0.620	90.2
0.660	91.9
0.700	93.0
λ	R_{nf} [41]§
0.779	92.0
0.910	94.4
1.096	96.0
1.329	97.3
1.718	97.5
2.204	98.0
3.842	98.0
4.810	98.1
6.264	98.2
7.737	98.5
λ	R_{of} [41]§
0.779	85.2
0.910	86.5
1.096	88.3
1.329	89.5
1.718	90.9
2.204	91.9
3.842	93.6
4.810	94.1
6.264	95.5
7.737	96.2

* [25]. † [51]. ‡ Light incident on glass side. §R_{nf} [R_{of}] = R for new [old] film.

Ag, Chem (Lacquered) [7]

λ	R_0
Before exposure*	
0.55	68.6
0.60	73.5
0.65	77.0
0.70	79.8
0.75	81.9
1.00	87.8
1.25	90.8
1.50	93.2
2.00	95.0
After exposure*	
0.55	62.0
0.60	68.7
0.65	73.8
0.70	77.5
0.75	80.5

* Exposed six hours to light from a 15 amp. carbon arc 0.5 meter away. Deterioration due presumably to the effect of ultra-violet light on the lacquer.

Au, Elec [22, 51]

λ	R_0
0.251	38.8
0.288	34.0
0.305	31.8
0.326	28.6
0.357	27.9
0.385	27.1
0.420	29.3
0.450	33.1
0.460	37.0*

Au, Elec.—(*Cont'd.*)

λ	R_0
0.480	38.0*
0.500	43.0*
0.520	53.0*
0.540	61.8*
0.560	70.8*
0.580	75.8*
0.600	79.2*
0.620	81.2*
0.640	84.0*
0.660	85.2*
0.680	85.3*
0.700	92.3
0.800	94.9
1.50	97.3
2.00	96.8
4.00	96.9
5.00	97.0
7.00	98.3
9.00	98.0
11.00	98.3
14.00	97.9

* [51].

Au, Chem [22]

λ	R_0
0.65	89.6
0.70	91.3
1.00	94.7
1.50	96.7
2.00	96.5
3.00	96.7
4.00	97.2
5.00	96.9
7.00	97.3
9.00	96.7
11.00	97.7
14.00	98.7

Cu, Elec [25, 51]

λ	R_0
0.188	23*
0.200	31*
0.251	26*
0.305	29*
0.357	32*
0.460	46.0
0.480	48.0
0.500	49.0
0.520	51.2
0.540	54.0
0.560	57.5
0.580	65.5
0.600	71.0
0.640	76.5
0.660	77.7
0.700	78.6

* [25].

Ni, Elec [22, 25]

λ	R_0
0.188	35*
0.200	44*
0.251	37.8
0.288	42.7
0.305	44.2
0.326	45.2
0.338	46.5
0.357	48.8
0.385	49.6
0.420	56.6
0.450	59.4
0.500	60.8
0.550	62.6
0.600	64.9
0.700	68.8
0.800	69.6

Ni, Elec.—(*Cont'd*)

λ	R_0
1.000	72.0
2.00	83.5
3.00	88.7
5.00	94.4
7.00	94.3
9.00	95.6
11.00	95.9
14.00	97.2

* [25].

Pt, Elec [22]

λ	R_0
0.251	33.8
0.288	38.8
0.305	39.8
0.326	41.4
0.357	43.4
0.385	45.4
0.420	51.8
0.450	54.7
0.500	58.4
0.550	61.1
0.600	64.2
0.650	66.5
0.700	69.0
0.800	70.3
1.00	72.9
1.50	77.7
2.00	80.6
3.00	88.8
4.00	91.5
5.00	93.5
7.00	95.5

TABLE 9.—TRANSMISSION, REFLECTION, AND ABSORPTION OF THIN FILMS OF PURE METALS

$R_0/100 = J_r/J_i$; $T/100 = J_t/J_i$; $A = 100 - (R_0 + T)$; τ = thickness of film. Ag is chemically deposited on glass, Au and Pt are deposited on quartz (SiO_2) by cathode sputtering. Unit of $\tau = 1\text{m}\mu = 10^{-3}\ \mu = 10^{-7}$ cm; of $\lambda = 1\mu = 10^4$Å $= 10^{-4}$ cm.

τ	48.6	79.0	100.4
λ	Ag [23]; *cf.* [24, 52], T		
0.221	7.0	2.5	
0.251	6.8	1.20	
0.288	10.2	2.92	1.32
0.305	23.2	10.3	4.6
0.310	33.4	14.6	8.2
0.316	39.8	26.7	19.7
0.321	44.1	31.6	22.5
0.326	39.4	25.4	16.9
0.332	27.6	15.9	10.0
0.338	20.7	10.2	3.63
0.357	11.8	4.16	0.81
0.385	9.90	2.38	0.43
0.420	8.85	1.30	0.32
0.450	6.80	0.84	0.24
0.500	5.32	0.40	0.10
0.55	4.12	0.27	0.076
0.60	3.36	0.142	0.050
0.65	2.78	0.106	0.034
0.7	2.55	0.079	0.025

TABLE 9.—(*Continued*)

τ	48.6	79.0	100.4
λ	Ag [23]; *cf.* [24, 52], T		
0.8	1.95	0.052	0.017
1.0	1.40	0.029	0.010
1.2	1.29	0.024	0.006
1.5	1.16	0.036	0.007

τ	53.3	73.2	101.1	20.9	51.5	89.9
λ	Au [23], T			Pt [23], T		
0.326	2.87	0.91		7.7		
0.357	3.98	1.06	0.306	7.6	0.49	
0.385	4.15	1.41	0.309	7.6	0.51	
0.42	5.10	1.74	0.440	7.1	0.57	
0.45	6.62	2.80	0.685	7.0	0.54	0.027
0.50	10.03	4.12	0.929	6.7	0.52	0.021
0.55	6.66	2.42	0.519	6.1	0.55	0.022
0.60	3.97	1.38	0.283	5.9	0.51	0.024
0.65	3.02	0.726	0.202	5.8	0.51	0.023
0.7	2.31	0.555	0.172	5.6	0.52	0.021
0.8	1.67	0.288	0.101	5.1	0.49	0.020
1.0	1.48	0.227	0.040	4.2	0.53	0.019
1.2	1.01	0.127	0.027	4.0	0.50	0.022
1.5	0.639	0.074	0.016	4.1	0.50	0.028
2.0	0.285	0.039		3.9	0.52	0.038
2.5	0.159	0.031		3.6	0.50	0.041

Pt [40], λ = 0.300

τ	R_f^*	R_q^*	T	A_f^*	A_q^*
0	7.9	7.9	82.6	0	0
1.0	9.9	5.8	67.4	15.1	21.0
2.7	12.8	5.0	53.6	27.2	38.4
4.2	15.7	6.0	46.9	31.6	45.9
10	25.8	11.7	24.7	46.1	62.8
15	28.1	14.7	19.2	50.0	65.2
22	28.6	19.4	9.1	60.9	70.5
50	26.4	19.3	0.5	73.0	80.6

Pt [40], λ = 0.400

τ	R_f^*	R_q^*	T	A_f^*	A_q^*
0	9.2	9.2	91.5	0	0
1.0	10.8	7.2	80.8	8.4	12.0
2.7	13.2	5.4	65.0	21.8	29.6
4.2	17.2	5.7	54.8	28.0	39.5
10	29.5	13.2	30.0	40.5	56.8
15	41.7	21.3	19.1	39.2	59.6
22	47.5	33.4	10.0	42.5	56.6
50	49.8	34.2	0.5	49.7	65.3

* R_f, A_f [R_q, A_q] = value of R, A when light is incident on film [on quartz] side of plate.

LITERATURE

(For a key to the periodicals see end of volume)

(1) Aster, *2*, **20**: 349; 22. (2) Bernoulli, *3*, **15**: 646; 09. (3) Betz, *8*, **18**: 590; 05. (4) Burgess and Foote, *31A*, **12**: 91; 15. (5) Coblentz, *152*, No. **65**: 91; 06. *31A*, **2**: 457; 06. (6) Coblentz, *31A*, **7**: 197; 11. (7) Coblentz, *31A*, **16**: 249; 20. (8) Coblentz and Hughes, *31A*, **19**: 577; 24. (9) Drude, *8*, **39**: 481; 90.

(10) Drude, *8*, **64**: 159; 98. (11) Duncan and Duncan, *2*, **1**: 294; 13. (12) Erochin, *3*, **39**: 213; 12. (13) Försterling and Fréedericksz, *8*, **40**: 201; 13. (14) Fréedericksz, *8*, **34**: 780; 11. (15) Frehafer, *2*, **15**: 110; 20. (16) Fritze, *8*, **47**: 763; 15. (17) Galli and Försterling, *183*, **1911 I**: 58. (18) Gardner, *21*, **45**: 30; 17. (19) Gaubert, *34*, **177**: 1123; 23.

(20) Graber, *2*, **26**: 380; 25. (21) Gripenberg, *63*, **14**: 123; 13. (22) Hagen and Rubens, *8*, **1**: 352; 00. **8**: 1; 02. **11**: 873; 03. (23) Hagen and Rubens, *8*, **8**: 432; 02. (24) Hartley, *172* (7th) **9**: 88; 10. (25) Hulburt, *21*, **42**: 205; 15. (26) Ingersoll and Littleton, *2*, **31**: 489; 10. (27) Kent, *2*, **14**: 459; 19. (27.1) Ketteler, *Theoretische Optik*, p. 122; 1885. (28) Lauch, *8*, **74**: 55; 24. (29) Lewis and Hardy, *2*, **14**: 272; 19.

(30) Littleton, *2*, **33**: 453; 11. (31) Meier, *8*, **31**: 1017; 10. (32) Meyer, *48*, **13**: 557; 26. (33) Miller, *48*, **10**: 621; 25. (34) Minor, *8*, **10**: 581; 03. (35) Morgan, *2*, **20**: 203; 22. (36) Nathanson, *2*, **11**: 227; 18. (37) Nathanson, *2*, **25**: 75; 25. (38) O'Brien, *2*, **27**: 93; 26. (39) Oppitz, *2*, **10**: 156; 17.

(40) Partzsch and Hallwachs, *8*, **41**: 247; 13. (41) Paschen, *8*, **4**: 304; 01. (42) Pirani, *63*, **13**: 753; 12. (43) Planck, *63*, **15**: 563; 14. (44) Pogány, *8*, **49**: 531; 16. (45) Quincke, *8*, **Jubelband**: 336; 74. (45.1) Schuster, *Theory of Optics*, p. 236; 1904. (46) Rother and Lauch, *63*, **24**: 462; 23. (47) Senftleben and Benedict, *8*, **54**: 65; 17. (48) Shea, *8*, **47**: 177; 92. (49) Skinner, *2*, **9**: 148; 17.

(50) Statescu, *8*, **33**: 1032; 10. (51) Tate, *2*, **34**: 321; 12. (52) Tear, *2*, **23**: 641; 24. (53) Tool, *2*, **31**: 1; 10. (54) Tyndall, *2*, **21**: 162; 23. (55) Uljanin, *63*, **11**: 784; 10. (56) Voigt, *8*, **23**: 104; 84. (57) von Wartenberg, *88*, **12**: 105; 10. (58) Weld, *48*, **6**: 67; 22. (59) Weniger and Pfund, *143*, **183**: 354; 17.

(60) Wheeler, *12*, **35**: 491; 13. (61) Wilsey, *2*, **8**: 391; 16. (62) Zakrzewski, *180*, **3**: 77; 10.

REFLECTIVITY: NON-METALS

E. P. T. TYNDALL

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TABLE 1.—SPECULAR REFLECTIVITY

Tabular values are $R \equiv 100 I_r/I_i$; I_r = intensity of radiation specularly reflected when intensity of incident radiation is I_i. λ_m = wave-length at which R is a local maximum, R_m = value of R at λ_m; $\|_o$, $\|_a$, $\|_b$, $\|_c$, $[\perp_o]$ = incident light is plane polarized with electric vector parallel to optic axis, to a, b, c crystallographic axis [$\perp$ to optic axis]. ——→ [———] indicates that $dR/d\lambda$ has the same sign [is essentially zero] throughout the region covered by the symbol; {indicates that R lies between the values so connected. In most cases, angle of incidence is nearly 0.

Table is spectrally subdivided; elementary substances are indicated by their symbols, others by the following key numbers (N_k):

N_k	Substance	N_k	Substance
1_l	H_2O, Water	6	CS_2
1_s	H_2O, Ice	7	CH_3OH, Methyl alcohol
2	H_2SO_4	8	C_2H_5OH, Ethyl alcohol
3	NH_4Cl	9	$C_3H_8O_3$, Glycerol
4	NH_4Br	10	C_6H_6, Benzene
5	Sb_2S_3, Stibnite	11	C_7H_8, Toluene

N_k	Substance	N_k	Substance	N_k	Substance	N_k	Substance
12	C_8H_{10}, Xylene	24	$(CuOH)_2CO_3$, Malachite	37	$BaSO_4$, Barite	46	Mica (muscovite)
13	C_9H_8O, Cinnamic aldehyde	25	Fe_2O_3, Hematite	38	$BaCO_3$, Witherite	47	Porcelain
14	$C_{10}H_7Br$, α-Bromonaphthalene	26	Fe_3O_4, Magnetite	39	$BaHgI_4.5H_2O$	48	Tourmaline
	SiO_2, (*see* Vol. VI)	27	FeS_2, Pyrites	40	NaCl, Rock salt	49	Cassia oil
15	$PbCl_2$	28	$FeCO_3$, Siderite	41	$NaNO_3$	50	Collodion
16	PbS, Galena	29	(Fe,Ni)S, Pentlandite		$LiNa(SeO_4)$	51	Kerosene
17	$PbSO_4$, Anglesite		$Co(NH_4)_2(SeO_4)_2$	42	KCl, Sylvite	52	Naphtha
18	$Pb(NO_3)_2$		$Ni(NH_4)_2(SeO_4)_2$	43	KBr	53	Paraffin
19	ZnS, Sphalerite	30	MoS_2, Molybdenite	44	KI	54	Paraffin oil
	$ZnSeO_4$	31	$Al_2(SO_4)_3(NH_4)_2SO_4.24H_2O$, Ammonium alum		$NiK_2(SeO_4)_2$	55	Vaseline (melted)
20	(ZnFe)S, Zinc blende	32	CaF_2, Fluorite	45	Carborundum		
21	$ZnCO_3$, Smithsonite	33	$CaCO_3$, Aragonite				
22	CuS, Covellite	34	$CaCO_3$, Calcite				
23	Cu_2S, Chalcocite	35	$SrSO_4$, Celestite				
		36	$SrCO_3$, Strontianite				

Additional data: (*a*) Infra-red: Aniline dyes [29], esters and salts of organic acids [22], inorganic salts [82]. (*b*) Aqueous solutions: Nitrides ($\lambda = 1$ to 10μ) [4], inorganic salts [22], effect of chlorides, nitrates, and sulfates in shifting the water maximum near $\lambda = 3\mu$ [5].

Unit of $\lambda = 1\mu = 10^4$ Å $= 10^{-4}$ cm

λ	Br	C*	Te	5	6	8	9	10	12	13	14	16	25
0.185													
0.20						3.7	5.5		6.0				
0.21	<4				6.0						6.0		
0.23		21			9.0						9.0		
0.25				50	4.0					0.5	6.0	40	
0.27					1.0					2.0	2.0		
0.29										4.0			
0.31				63						2.0			
0.32													
0.33										0.8		50	
0.40						2.0	4.0	4.0	4.0				
0.44				40								40	
0.45	<4		30	50								45	
0.546		.17	30										
0.600			30										
0.645				40								40	25
0.72				50								45	
0.75													
Lit.	(27)	(53)	(81, 88)	(12, 15, 18, 32, 87)	(27, 42, 49)	(49)	(49)	(49)	(49)	(27, 42, 49)	(27, 42, 49)	(12, 15, 32, 87)	(12, 32)

λ	27	30	32	34	39	40	49	51	52	53	54	55
0.185			8†	13		8						
0.20								3.1	3.2	3.5	3.5	3.5
0.21					<4							
0.23		54										
0.25	47	58					0.5					
0.27							2.0					
0.29							4.0					
0.31							2.0					
0.32	50											
0.33		48			<4		0.8					
0.40	39							2.2	2.2	2.5	2.2	2.5
0.44	43											
0.45		59										
0.546	53	41‡										
0.600	53	45‡	3§									
0.645		43‡										
0.72	62	51‡										
0.75		47	3									
Lit.	(12, 15, 33, 87)	(13, 15, 16, 18, 33, 87)	(47)	(36)	(27, 42, 49)	(36)	(27, 42, 49)	(49)	(49)	(49)	(49)	(49)

TABLE 1.—(*Continued*)

λ = 1 to 21μ; incident light unpolarized; for **1, 7, 8, 10, 11, 34, 45, 46, 47, 48,** *see infra*

λ	C*	S	5	16	19	22	23	25	26	27	29	30	32	50
1	16.5		40	30	10	45	15	12	5	30	15	30	3	
3		8					↓							
6							50							10
7													3	
10							↓							10
11			40				56							
12										30		30		
13					10									
14		8		30		76	56	12	38		48			
19	16.5													
Lit.	(63)	(13, 70, 74)	(12, 15, 18, 32, 87)	(12, 15, 32, 87)	(12, 18)	(13)	(13)	(12, 32)	(12)	(12, 15, 33, 87)	(13)	(13, 15, 16, 18, 33, 87)	(47)	(86)

λ	1_l	1_s	7	8	10	11
Lit.	(3, 9, 22, 72, 73)	(8)	(3)	(3, 72)	(3)	(3)
1.0	1.98	1.72	1.95	2.25	3.85	3.90
1.5	1.95	1.62	1.95	2.20	3.81	3.90
2.0	1.74	1.62	1.85	2.05	3.75	3.85
2.4	1.45	1.13	1.77	1.82	3.55	
2.6	1.25	0.73		1.67	3.35	3.70
2.8	1.35	0.70	1.35	1.45	3.40	3.60
3.0	3.40	1.60	1.95	1.75	3.60	3.80
3.2	4.10	5.10	2.05	2.10	3.35	3.65
3.4	3.25	3.90	1.80	2.00	3.45	3.55
3.5	2.95	2.81	1.92	2.12	3.67	3.77
4.0	2.20	1.75	2.15	2.50	4.00	3.95
4.5	2.14	(22)	2.15	2.60	3.84	3.90
5.0	2.00		2.15	2.40		3.90
5.5	1.68	1_l		2.20		3.60
5.6	1.67	$\angle i = 50°$				
5.8	1.40					3.80
5.9	1.50					
6.0	2.00	4.00		2.05		
6.1	2.28					
6.2	2.46					
6.3	2.34					
6.5	2.10			2.00		
7.0	1.95	3.25		2.00		
7.5	1.75			2.03		
8.0	1.67	3.20		2.20		
8.5	1.60			2.30		
9.0	1.44	2.50		1.70		
9.5	1.24			2.05		
10.0	0.95	2.10		3.03		
10.5	0.85			10.75		
11.0	0.75	1.80		2.40		
11.5	1.10			2.70		
12.0	2.00	2.80		2.80		
12.5	2.00			2.65		
13.0	3.10	4.70		2.85		
13.5	3.40					
14.0	4.10	6.65		3.00		
14.5	4.80					
15.0	5.30	8.20		3.00		
15.5	5.4					
16.0	5.3	8.7		3.0		
16.5	6.0					
17.0	6.6	9.8		2.8		
17.5	6.9					
18.0	6.7	11.3		2.9		

λ	1_l	1_l; $\angle i$ = 50°	7	8	10	11
Lit.	(3, 9, 22, 72, 73)	(22)	(3)	(3, 72)	(3)	(3)
18.5	7.5					
19.0	8.4	13.7		2.9		
20.0	8.9					
21.0	8.2					

λ	$34_o^{\parallel}$	$34_e^{\parallel}$	45	46	47	$48_o^{\parallel}$	$48_e^{\parallel}$
1.0			15.0			5.9	5.5
2.0	25.0	21.0				5.7	5.5
2.5						5.6	5.3
3.0	17.0	20.0				5.5	5.7
4.0	13.0	17.0	17.0		1.0	4.9	5.1
5.0	11.0	15.0				4.2	4.5
6.0	3.0	11.0	18.0	3.0	1.0	3.3	3.8
6.5	90.0	11.5		3.5		1.0	3.4
7.0	95.0	9.0		2.0		0.5	2.7
7.5	45.0	9.0		1.5		17.0	3.0
8.0	32.0	9.0	18.0	1.0	0.5	12.0	1.0
8.5				4.0	9.0	3.0	2.0
9.0	21.0	8.0	17.0	35.0	13.0	12.0	37.0
9.25				38.0	16.0	11.0	21.0
9.5			14.0	29.0	13.0	30.0	30.0
9.75				40.0		38.0	25.0
10.0	22.0	7.0	7.0	27.0	8.0	40.0	20.0
10.25			6.0				
10.5			32.0	13.0	7.0	25.0	17.0
11.0	26.0	2.0	80.0	10.0	5.5	15.0	8.0
11.25	27.0	89.0					
11.5		50.0	94.0				
12.0	24.0	17.0	98.0		2.0	9.0	2.0
12.5			91.0			8.0	25.0
13.0	18.0	13.0	63.0			5.0	24.0
13.5			55.0			10.0	2.0
14.0	15.0	8.0	53.0			7.0	30.0
14.25	25.0	8.0				3.0	39.0
14.5	22.0	11.0					
15.0						2.0	15.0
Lit.	(52)	(52)	(13)	(12, 13)	(13)	(13, 63)	(13, 63)

* Diamond.

† (36).

‡ 41, 45, 43, 51 correspond to λ = 0.590, 0.610, 0.640, 0.69; λ_m at 0.250, 0.450, 0.610, 0.690μ. At −160°C, λ_m shifted from 0.61 and 0.69 to 0.595 and 0.655μ, and maxima are enhanced.

§ R = 3 from λ = 0.6μ to λ = 7.0.

$\parallel$ o = ordinary, e = extraordinary ray.

λ = 1 to 21μ; incident light polarized [79]

Substance		λ_m	R_m	Substance		λ_m	R_m
$ZnSeO_4$	$\parallel_o$	11.43	30	$Ni(NH_4)_2(SeO_4)_2$.—(*Cont'd*)	$\parallel_c$	11.15	5
$ZnSeO_4$	$\perp_o$	11.48	18	$LiNaSeO_4$	$\parallel_o$	11.42	13
$Co(NH_4)_2(SeO_4)_2$	$\parallel_a$	11.56	9		$\perp_o$	11.30	19
	$\parallel_b$	11.22	6	$NiK_2(SeO_4)_2$	$\parallel_a$	11.32	15
	$\parallel_c$	11.12	5		$\parallel_b$	11.56	17
$Ni(NH_4)_2(SeO_4)_2$	$\parallel_a$	11.42	9		$\parallel_c$	11.18	10
	$\parallel_b$	11.30	6				

λ = 22 to 310μ; incident light not polarized

λ =	22	23	27	33	39	52	63	83	94	117	310	Lit.
S		11¶				9.2						(13, 70, 74)
1_I		6.5		7.2		9.3	10.6	10.9	11.1	12.7**	15.1**	(69)
2		8.8		7.9		16.9	18.7	17.7	17.7	18.4	21.7	(69)
3		3.8		3.1		79.5	54.7	32.3	26.3	23.4	19.8	(69)
4		6.0		3.8		55.1	66.4	41.5	28.8	24.4	21.1	(69)
9		5.8		5.5		5.2	6.3	7.5		8.5	9.4	(69)
15		10.2		6.9		23.3	43.2	61.8	71.4	58.9	51.8	(69)
18	6.9		6.2	5.5	3.1	5.0	29.4	63.7	55.8	50.8	36.9	(38)
20	7.2		35.4	73.7	51.9	30.3	27.7	25.5	25.0	24.4	23.5	(38)
24	8.5			32.4	23.6	20.0	23.5	24.2	24.0	22.2††	20.8	(38)
31	6.5		4.4	5.7	9.2	18.9	18.0	16.0	15.1	17.7	17.8	(38)
32		55.3		83.0		30.0	25.2	21.6	20.4	20.6	19.9	(69)
40		2.1		1.7		80.2	64.5	27.5	24.3	19.9	17.9	(69)
42		2.3		1.6		39.9	80.0	37.5	24.4	17.4	14.0	(69)
43		3.8		3.2		2.2	18.0	82.8	56.3	21.9	14.9	(69)
44		5.6		4.4		2.2	2.3	30.2	75.0	23.0	15.8	(69)

λ = 22 to 310μ; incident light plane polarized

λ =	22	27	33	39	52	63	83	94	110	117	310	Lit.
17 $\parallel_b$	3.2		43.7	36.2	32.8	20.5	18.5		17.4		17.2	(37)
17 $\parallel_c$	2.5		55.4	54.9	35.3	22.9	18.7		18.5		18.3	(37)
21 $\parallel_o$	2.2	15.4	20.4	29.0	79.0	75.9	41.5	31.9		29.6	25.7	(38)
21 $\perp_o$	3.7	21.7	45.5	32.6	59.5	50.4	33.8	31.7		29.5	25.4	(38)
28 $\parallel_o$	5.7	30.8	20.2	30.2	69.7	41.5	25.7	22.5		21.1	17.7	(38)
28 $\perp_o$	5.5	42.4	46.5	31.0	39.1	31.7	25.9	24.3		23.5	22.3	(38)
33 $\parallel_a$	0.84		60.3	66.0	44.3	28.8	22.9	22.7	19.9		19.7	(37)
33 $\parallel_b$	1.5		67.1	71.8	51.2	27.4	21.4	27.7	28.8		27.9	(37)
33 $\parallel_c$	1.9		62.5	51.7	42.1	29.2	24.2	24.7	22.4		21.8	(37)
34 $\parallel_o$			50.4	29.5	8.2	2.2	48.4	80.8		48.3	28.9	(37)
34 $\perp_o$			64.5	43.2	25.8	15.9	26.2	58.0		38.5	27.2	(37)
35 $\parallel_a$	5.4		8.8	30.6	57.2	33.4	54.3	44.1	31.3		25.6	(37)
35 $\parallel_b$	6.2		6.1	14.4	57.5	66.7	15.5	13.9	53.7		54.5	(37)
35 $\parallel_c$	5.4		10.2	41.4	48.7	21.9	28.5	27.7	26.2		23.9	(37)
36 $\parallel_c$	1.5		18.9	48.0	62.0	42.5	25.5	22.1	20.3		19.1	(39)
36 $\perp_c$	2.4		24.9	50.5	39.0	28.2	23.5	22.1	20.5		19.3	(39)
37 $\parallel_a$	6.0		5.7	6.4	41.2	55.5	36.4	45.5	34.3		25.2	(37)
37 $\parallel_b$	6.9		5.7	5.9	40.9	56.5	13.4	33.0	52.2		43.3	(37)
37 $\parallel_c$	6.3		8.2	22.2	68.1	37.5	24.2	17.4	29.4		26.7	(37)
38 $\parallel_o$	2.1		12.9	40.4	86.0	78.9	37.7	26.1	24.4		21.1	(38)
38 $\perp_o$	4.5		15.0	52.1	66.5	38.1	28.4	25.2	24.6		21.6	(38)
41 $\parallel_o$	1.7	0.6	6.6	21.0	22.2	11.1	4.1	2.9		36.7	38.0	(38)
41 $\perp_o$	3.5	2.4	8.7	26.5	29.9	18.1	11.7	8.5		20.9	19.1	(38)
48 $\parallel_o$	33.7		17.2		16.2	15.8	17.7			18.1	18.1	(38)
48 $\perp_o$	33.9		24.2		22.6	21.3	22.0			22.2	21.1	(38)
48‡‡ $\parallel_o$	29.2		14.4	19.9	17.3	15.2	16.8	19.0		18.3	17.8	(37)
48‡‡ $\perp_o$	32.3		22.1	24.2	23.1	17.1	22.1	21.5		21.3	20.0	(37)

¶ For λ = 24μ.
** At 0°C, $R_{117\mu}$ = 11.8, $R_{310\mu}$ = 14.9; at 30°C, $R_{117\mu}$ = 13.2, $R_{310\mu}$ = 17.1.
†† For λ = 110.
‡‡ Red tourmaline.

TABLE 2.—WAVE-LENGTHS (λ_m) OF MAXIMA OF SPECULAR REFLECTIVITY

Incident light unpolarized except for $ZnSeO_4$ to $NiK_2(SeO_4)_2$ where data are marked thus: $\|_o$, $\|_a$, $\|_b$, $\|_c$, [$\perp_o$] = plane of electric vector is parallel to optic axis, to *a*, *b*, *c* crystallographic axis, [perpendicular to optic axis].

Additional Data.—λ_m for Nd-compounds, visible (34); effect of water of crystallization on λ_m in infra-red, alums, sulfates, selenates (9, 77); aqueous solutions of salts of strong acids (5). Unit of $\lambda_m = 1\mu = 10^4$ Å $= 10^{-4}$ cm. *See also* Tables 1 and 3.

Substance	λ_m		
(80)			
$AgClO_3$	10.76	16.38	–
$Ba(ClO_3)_2$	10.24		19.6
$KClO_3$	10.12	16.22	
$NaClO_3$	10.04	16.04	
(80)			
$AgBrO_3$		12.6	13.1
$Ba(BrO_3)_2$	12.3	12.64	
$Cd(BrO_3)_2$	12.3		13.2
$NaBrO_3$	12.2		
(12, 31, 54, 61, 76)			
H_2SO_4	7.2	8.6	10.4
H_2SO_4*	8.6	9.6	11.35
$BaSO_4$	8.9		15.8
$BeSO_4$	8.82	9.08	16.04
$CaSO_4$	8.68		14.84
$CdSO_4$		9.05	15.96
$CoSO_4$		9.05	
$CuSO_4$		9.15	15.88
$FeSO_4$		9.1	
$Fe_2(SO_4)_3$		9.05	
K_2SO_4	8.83		15.92
Li_2SO_4	8.76		15.32
$MgSO_4$	8.70	9.25	
Na_2SO_4	8.72†	9.02	16.08†
$NiSO_4$		9.04	15.74
$SrSO_4$	8.4	9.1	15.75
$ZnSO_4$		9.2	
$M(NH_4)_2(SO_4)_2$‡		9	16
$MK_2(SO_4)_2$‡		9	16
K, Alum§		9.04	16.74
(57)			
$KHSO_3$	8.21		
(79)			
$CdSeO_4$	11.44		
$CuSeO_4$	11.52		
K_2SeO_4	11.20		
$Mn_2(SeO_4)_3$	11.36		
$NiSeO_4$	11.44		
		$\|_o$	$\perp_o$
$ZnSeO_4$	11.44	11.43	11.48
$LiNaSeO_4$		11.42	11.30
	$\|_a$	$\|_b$	$\|_c$
$Co(NH_4)_2(SeO_4)_2$	11.56	11.22	11.12
$Ni(NH_4)_2(SeO_4)_2$	11.42	11.30	11.15
$NiK_2(SeO_4)_2$	11.32	11.56	11.18
(12, 54, 78)			
HNO_3	7.85	10.55	
$AgNO_3$	7.45		
$Ba(NO_3)_2$	7.3	13.7	15.6
$HgNO_3$	8.06	12.5	15.9
	10.08		
KNO_3	7.13		
$NaNO_3$	7.12	12.04	14.44
$Pb(NO_3)_2$	7.72	13.9	15.9
$Rb(NO_3)$	7.24	12.3	15.2
$Sr(NO_3)_2$	7.28	12.36	15.36

Substance	λ_m			
(12, 35)				
$AlPO_4$	9.25	9.7		
$BiPO_4$	9.2 to 10.0	10.9	16.6 to 18.15	18.6 to 19.15
$Ca_3(PO_4)_2$	9.5			
Li_3PO_4	9.25		16.4 to 19.1	
$Mg_3(PO_4)_2$	9.4	10.5		17.1
Na_3PO_4	9.6		17.5 to 18.0	
$Pb_3(PO_4)_2$		10.15	17.25 to 18.7	
$Sr_3(PO_4)_2$	8.7 to 9.8			
$Zn_3(PO_4)_2$	9.4			16.6
$Na_4P_4O_{12}$	7.9 to 9.15 to 11.16			19.0

Substance	λ_m		
(35)			
$Ag_4P_2O_7$	9.2 to 11.2	14.3 to 19.3	
$K_4P_2O_7$	7.75 to 9.05	11.2 to 14.8	18.7 to 19.15
$Na_4P_2O_7$	8.5 to 10.9	12.5 to 13.6	17.4 to 18.7
$Pb_2P_2O_7$	8.0 to 8.95	9.9 to 11.1	13.5

Substance	λ_m		
(12, 13, 45, 57, 76)			
$BaCO_3$‖	6.85	11.6	14.5
$CaCO_3$¶	6.7	11.4	14.2
$Cu_3(CO_3)_2(OH)_2$**	7.0	11.92	14.16
	10.54		
$(CuOH)_2CO_3$)††	7.2	11.56	13.32
	6.65	9.64	12.14
$CaMg(CO_3)_2$‡‡	6.9	11.5	14.7
$FeCO_3$§§	6.8	11.5	13.7
$MgCO_3$‖‖	6.62	11.32	
$MnCO_3$¶¶	6.7	11.42	14.0
Na_2CO_3	7.0	11.48	14.56
$PbCO_3$***	7.1	11.97	15.0
$SrCO_3$†††	6.74	11.6	14.32
$ZnCO_3$‡‡‡	6.76	11.4	13.71

Substance	λ_m			
(11, 57, 79)				
Ag_2CrO_4	11.45 to 11.95			
$Ag_2Cr_2O_7$	10.78 to 11.15		11.54 to 11.88	14.05
$BaCrO_4$	11.08	11.58		
$CaCrO_4$	10.96			
K_2CrO_4	10.88 to 11.10			
$K_2Cr_2O_7$	10.35		12.5	
Li_2CrO_4	10.75			
$MgCrO_4$	10.90			
$PbCrO_4$	11.45 to 11.65 to 12.10			
$SrCrO_4$	10.65 to 11.35 to 11.80			
$C_3H_8O_3$§§§	4.8	9.7 (54)		

* $H_2SO_4 + xH_2O$.
† Thenardite.
‡ M = Co, Cu, Mg, Mn, Ni, or Zn.
§ $Al_2(SO_4)_3.K_2SO_4.24H_2O$; nearly same λ_m for other alums.
‖ Witherite.
¶ Same λ_m for calcite, marble, and aragonite.
** Azurite.
†† Malachite.
‡‡ Dolomite.
§§ Siderite.
‖‖ Magnesite.
¶¶ Rhodochrosite.
*** Cerussite.
††† Strontianite.
‡‡‡ Smithsonite.
§§§ Glycerol.

TABLE 3.—WAVE-LENGTHS OF RESIDUAL RAYS

After many reflections from a given material the reflected radiation contains only a few ("residual") wave-lengths in the range 18μ to 150μ. Unit of $\lambda = 1\mu = 10^4$ Å $= 10^{-4}$ cm.

Substance	λ		λ	λ_{mean}	Lit.
NH_4Cl	46.3		54.0	51.5	(48, 75)
NH_4Br	55.3		62.3	59.3	(75)
SiO_2 (*see* Vol. VI)					
$PbCl_2$	74	92	114	91	(68)
TlCl		91.6			(75)
TlBr		117			(75)
TlI		151.8			(75)
$HgCl_2$		95			(68)
Hg_2Cl_2	91.6		117.8	98.8	(68)
AgCl	74		90	81.5	(68)
AgBr		112.7			(68)
AgCN		93			(75)
$MgCO_3$*		30.2			(13)
CaF_2†	24.0	31.6			(66, 74)
CaF_2†‡	22.0	33.0			(19)
$CaCO_3$§		29.4			(6)
$CaCO_3$‖	93		116	98.7	(67, 68)
$CaCO_3$¶		39			(37)
$SrCO_3$**	43.2				(48)
$BaCO_3$††		46			(48)
NaCl‡‡	47		54	52	(48, 68, 70, 71)
NaCl‡ ‡‡		52			(19)
NaBr	50 to 55				(6)
KCl§§	62.3		70.6	63.4	(68, 70, 71)
KCl‡§§		63			(19)
KBr	74.0		86.0	83.3	(6, 68, 71)
KBr‡		83			(19)
KI		96			(68, 71)
KI‡		94			(19)
$H_2KAl_3(SiO_4)_2$‖‖	18.4		21.5		(13, 74)

* Magnesite.
† Fluorite.
‡ Using only one reflecting surface and plane polarized light incident at the polarizing angle.
§ Marble.
‖ Calcite.
¶ Aragonite.
** Strontianite.
†† Witherite.
‡‡ Rock salt.
§§ Sylvite.
‖‖ Muscovite (mica).

TABLE 4.—POLARIZATION OF LIGHT BY REFLECTION FROM LIQUIDS

When unpolarized light is reflected at the boundary of two substances it is partially polarized; if for the reflected light $I_\parallel$ [$I_\perp$] = amplitude of component of the electric vector parallel [perpendicular] to the plane of incidence, $I_\perp > I_\parallel$. The angle at which $(I_\parallel/I_\perp)$ is a minimum is called Brewsterian angle; at that angle $(I_\parallel/I_\perp) \equiv k \times 10^{-5}$. Data apply to clean surfaces.

Substance (60)	k
H_2O, Water	75*
CCl_4, Carbon tetrachloride	84
CS_2, Carbon disulfide	142
CH_4O, Methyl alcohol	69
C_2H_6O, Ethyl alcohol	66
C_3H_6O, Allyl alcohol	110
C_3H_6O, Acetone	81
C_3H_8O, *n*-Propyl alcohol	96
C_3H_8O, Isopropyl alcohol	110
$C_3H_8O_3$, Glycerol	0
$C_4H_{10}O$, *n*-Butyl alcohol	92
$C_4H_{10}O$, Isobutyl alcohol	87
C_5H_{12}, *n*-Pentane	170
$C_5H_{12}O$, Amyl alcohol	150
$C_6H_5NO_2$, Nitrobenzene	131
C_6H_6, Benzene	107
C_7H_8, Toluene	194
C_8H_{10}, *m*-Xylene	202
C_8H_{18}, Octane	66
$C_{16}H_{32}O_2$, Palmitic acid	190
$C_{18}H_{34}O_2$, Oleic acid	210
Olive oil	107

* Rayleigh (62) gives for H_2O, $k = 42$.

Diffusion Diagrams.—When light is diffusely reflected, the intensity $(I_{r\theta})$ of the light reflected at the angle θ depends upon the intensity (I_i) of the incident light and also upon the angle (i) of incidence, and varies with θ. The distribution of the reflected light when the surface is illuminated by a beam of parallel light may be shown by a diffusion diagram (Figs. 1 to 4) in which the value of $(I_{r\theta})$ for any value of θ is represented by a point at a distance equal to $(I_{r\theta})$ from a common center and in the direction θ. If $I_{r\theta} = I_{r0} \cos \theta$, these points will lie upon a circle tangent to the surface. Data additional to Figs. 1 to 4: Diffusion by non-metals (1, 7, 23, 24, 43, 90), by roughened metals (44); polarization and depolarization by diffuse reflection (10, 46).

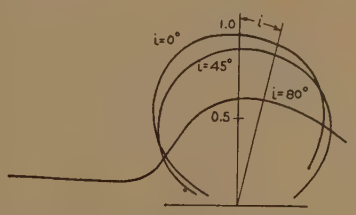

FIG. 1.—Diffusion diagram: MgO (89).
$\lambda = 0.55\mu$; unit intensity = $(I_{r0})_{i=0}$.

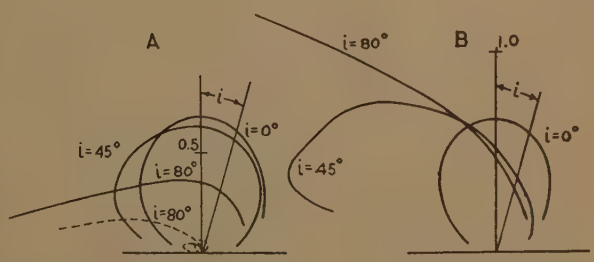

FIG. 2.—Diffusion diagram: Rhodamine B on white drawing paper (89).
Unit intensity = $(I_{r0})_{i=0}$ for MgO. In A, —— $\lambda = 0.65\mu$, - - - $\lambda = 0.55\mu$; in B, $\lambda = 0.55\mu$.

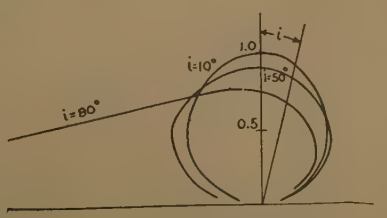

FIG. 3.—Diffusion diagram: Roughened milk glass (88).
White light, glass roughened with emery paper; unit intensity = $(I_{r0})_{i=0}$.

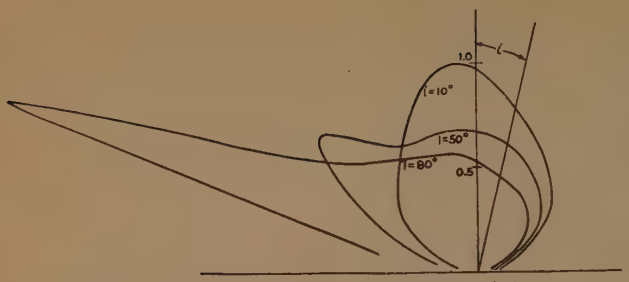

FIG. 4.—Diffusion diagram: $CaSO_4$ plaque (85).

White light; plaster of Paris ($CaSO_4$) cast on a glass surface, reflection from the smooth surface; unit intensity = $(I_{r\theta})_{i=0}$.

TABLE 5.—ALBEDO: WHITE LIGHT

A = Albedo = F_r/F; F_r = total luminous flux (in complete hemisphere) reflected from a plain surface coated with the material and uniformly illuminated with white light, the total luminous flux incident upon it being F. Pg = ground pigment; Pt = applied and dried paint; w Pg = white pigment. Paints and pigments are arranged in the order: Black, white, gray, red, yellow, green, blue, purple. Same system of key numbers (N) for Tables 5 and 6. Unit of A = 0.01 = 1%.

N	Substance		A	Lit.
2	H_2O, snow		93*	(51)
3	H_3BO_3		94*	(51)
4	Al_2O_3		94*	(51)
9	MgO		97*	(26, 51, 55)
11	$HSbO_2$	w Pg	89	(21)
13	ZnO	w Pg	91	(21)
14	$CaCO_3$		95*	(51)
15	$MgCO_3$		98	(30, 55, 84)
17	$BaSO_4$	w Pg	88	(21)
18	Munsell cards:			
	Gray	*N*9	74	(59)
		*N*7	47	(59)
		*N*5	24	(59)
		*N*3	9	(59)
		*N*1	2	(59)
	Red	r 7/5	46	(59)
		r 5/5	22	(59)
		r 3/2	9	(59)
	Yellow	y 7/4	50	(59)
		y 5/5	28	(59)
		y 3/2	10	(59)
	Green	g 7/4	49	(59)
		g 5/5	25	(59)
		g 3/2	9	(59)
	Blue	b 7/4	49	(59)
		b 5/5	26	(59)
		b 3/2	9	(59)
	Purple	p 7/3	51	(59)
		p 5/5	25	(59)
		p 3/2	9	(59)
21	China clay†	Pg	84	(21)
22	Flat white x	Pt	71	(21)
23	Gloss white X	Pt	65	(21)
24	Lithopone	Pg	91	(21)
26	Titanium oxide	Pg	91	(21)
28	White lead‡	Pg	90	(21)
31	Gray, light	Pt	49	(21)
32	Gray, medium	Pt	30	(21)
33	Pink, light	Pt	67	(21)
34	F_1, red-brown§	Pt	6.37	(58)
	F_2, red-brown§	Pt	6.46	(58)
35	Red	Pt	13	(21)
36	Venetian red	Pg	11	(41)
37	Vermilion (Amer.)	Pg	14	(41)
38	Burnt sienna	Pg	11	(41)
39	Chrome yellow	Pg	55	(41)
40	Yellow, light	Pt	65	(21)
41	Cream, light	Pt	74	(21)
42	Chrome green	Pg	20	(41)
43	A_1, green§	Pt	32.0	(58)
	A_2, green§	Pt	32.4	(58)
44	Green, dark	Pt	12	(21)
45	Green, light	Pt	47	(21)
46	Cobalt blue	Pg	7	(41)
47	C_1, blue§	Pt	19.6	(58)
	C_2, blue§	Pt	19.1	(58)
48	Blue, light	Pt	61	(21)
49	Blue, medium	Pt	36	(21)
50	B_1, red-purple§	Pt	24.8	(58)
	B_2, red-purple§	Pt	24.6	(58)
	Airship fabric (Al coated)		33	(20)
	Airship fabric (black r.)‖		6	(20)
	Black velvet		*ca.* 1	(14, 83)
	Brown soil		32	(28)
	Green leaves		*ca.* 25	(2, 14, 28)
	Ink (various kinds)		1 to 4	(50)
	Paper, white		70 to 80	(2, 28, 55, 83)
	Print		60	(50)
	Science abstracts		62	(50)
	Azo¶ A (matt)		72	(50)
	Azo¶ C (glossy)		74	(50)
	Plaster (raw)		45	(50)
	Plaster (finished)		65	(50)
	Cement and lampblack, *see* (84)			

* Value corrected to agree with A = 98 % for $MgCO_3$.
† Kaolin.
‡ Basic carbonate.
§ Camouflage paint.
‖ Coated with black rubber.
¶ Photographic paper.

TABLE 6.—MONOCHROMATIC ALBEDO

A_λ = Monochromatic albedo = $F_{\lambda r}/F_\lambda$; $F_{\lambda r}$ = total flux (in complete hemisphere) of radiant energy of wave-length λ reflected from a plain surface coated with the material and uniformly illuminated with radiation of wave-length λ, the total radiant flux of this λ incident upon it being F_λ. Normal incidence: Pg = powdered pigment; Pt = applied paint; b = black, gn = green, gy = gray, w = white, y = yellow. Same system of key numbers (N) for Tables 5 and 6. Additional data: Flowers (64), paints (25), pigments (ultra-violet) (17). Unit of A_λ = 0.01 = 1%; of $\lambda = 1\mu = 10^4 Å = 10^{-4}$ cm.

	λ		0.2536	0.3131	0.3655	0.4047	0.4358
N	Material		A_λ (56)				
1	S				7	8	18
13	ZnO	Pg			2	70	93
24	Lithopone	Pg		5	70	77	95
25	Timonox	Pg	5	35	60	85	90
27	Titanox	Pg		5	30	80	87
28	White lead*	Pg	5	60	75	75	90
29	White lead†	Pg	5	17	17	70	83

* Basic carbonate.
† Sublimed.

λ		0.44	0.46	0.50	0.52	0.54	0.56	0.58	0.60	0.62	0.64	0.66	0.68	0.70	0.74
N	Material	A_λ (40, 58)													
9	MgO‡														
37	Vermilion (Amer.)§	Pg	8	6	5	6	6	9	11	24	39	53	61	66	65	
38	Burnt sienna§	Pg	4	4	4	5	6	9	14	18	20	21	23	24	25	
39	Chrome yellow§	Pg	5	5	8	18	48	66	75	78	79	81	81	81	81	
43	A_1, green‖	Pt		23	28	33	37	36	34	28	24	21	18	16	15	13
	A_2, green‖	Pt		22	38	45	36	31	27	27	27	28	39	54	67	17
50	B_1, red-purple‖	Pt		27	22	21	21	22	26	32	32	29	27	24	23	21
	B_2, red-purple‖	Pt		28	23	22	23	22	24	28	31	33	43	58	70	76
47	C_1, blue‖	Pt		36	29	25	22	19	16	14	13	12	10	9	9	9
	C_2, blue‖	Pt		37	39	28	18	15	13	13	13	14	22	37	55	71
34	F_1, red-brown‖	Pt		4	4	5	5	5	7	9	11	10	11	10	10	9
	F_2, red-brown‖	Pt		5	7	5	5	6	6	8	8	9	14	26	42	63

‡ Effect of thickness (t) of MgO applied to colorimeter plate; kind of plate is not stated (55):

t	0.1	0.35	0.6 mm
100 A_{red}/A_{green}	99.3	100.0	100.3
100 A_{blue}/A_{green}	101.5	100.0	99.3

§ From Sherwin Williams Paint Co.
‖ Camouflage paint (58).

λ		0.6	0.95	4.4	8.8	24
N	Material	A_λ (14)				
5	CaO	w Pg	85		22	4	6
6	Co_2O_3	gy Pg	3	4	14	13	6
7	Cr_2O_3	gn Pg	27	45	33	5	8
8	CuO	b Pg		24	15		4
9	MgO	w Pg	86		16	3	9
10	PbO	Pg	52		51	26	10
12	ThO_2	Pg	86		47	7	10
13	ZnO	y Pg	82	86	9	3	5
13	Zinc oxide No. 104¶	Pt	68	72			
15	$MgCO_3$	w Pg	85	89	11	4	9
19	Lampblack	Pt	3	3.4	3.5	3.8	4.4
19	Lampblack (various flames)			1.0	1.0	1.5	4
20	Platinum black, paint	Pt	2	2.7	5.9	8.7	12.1
	Electrolytic, 1 min.**			1	1.5	25	
	Electrolytic, 2 to 3 min.**			1	1.5	11	7.5
	Electrolytic, 3 min. ** (65)			1.5	6	7	
	Electrolytic, 4 to 6 min.**			1	1.5	2	4
28	White lead No. 103¶	Pt	76	79			
30	Zinc lead white No. 107¶	Pt	70				

¶ In linseed oil; Sherwin Williams Paint Co.'s number.
** Electrolytically deposited on Pt (14) [on Ag (65)] for time indicated.

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(For a key to the periodicals see end of volume)

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TOTAL (NON-SPECTRAL) TRANSMISSION OF RADIATION

JOHN W. T. WALSH AND H. BUCKLEY

Data for the transmission of long electric waves, X-rays and gamma rays are excluded from this section; for the rest of the spectrum reliable quantitative data for the total transmission are available for only a very few substances. For spectral transmission, *v.* p. 268 and 359.

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SYMBOLS

(*v. also* Vol. I, p. 16; others defined where used)

I [I'] Intensity of radiation incident upon [transmitted by] a given plate of material. $I = \int_0^\infty I_\lambda d\lambda$; $I' = \int_0^\infty I'_\lambda d\lambda$.

I_l [I'_l] Luminous intensity of I [I']. $I_l = \int_0^\infty \Lambda_\lambda I_\lambda d\lambda$.

P Pressure.

p % defect in polarization = 100 w/s.

S_t Intensity of light scattered by the substance at temperature t.

S_a [S_{a35}] Intensity of light scattered by air at t = 0°C, P = 760 mm of Hg [by liquid $(C_2H_5)_2O$ at 35°C].

s [w] Strongest [weakest] plane polarized component of the scattered light.

t Temperature, °C.

w *See* s.

α Absorption factor = $(I - I')/I = 1 - \tau$; $\alpha_l = 1 - \tau_l$. Reflection losses taken as zero.

β Angle observed light makes with incident beam.

θ [φ] Angle of view [of incidence] measured from normal to surface.

Λ_λ Visibility factor. $I_l = \int_0^\infty \Lambda_\lambda I_\lambda d\lambda$.

τ Transmission factor = I'/I; $\tau_l = I'_l/I_l$, reflection losses being taken as zero.

TABLE 1.—TRANSMISSION FACTOR FOR RADIATION (τ) AND LIGHT (τ_l) FROM A BLACK-BODY

T = temperature of the black-body (°K); x = thickness of transmitting plate (mm)

T		2400	3600*	5000	2400†	3600*	5000‡	Lit.
Substance	x	100τ			100α_l			
H_2O, Water	10	22.5	50	69	0.10	0.08	0.07	(1, 2, 14)
	100	9	31.5	54	1.04	0.84	0.74	(1, 2, 14)
SiO_2, Quartz	10	90	98.5	99	Practically zero			(13)
	100	84	95	98	Practically zero			(13)
NaCl, Rock salt		Very great			Practically zero			(13)
KCl, Sylvite		Very great			Practically zero			(13)
CaF_2, Fluorite		Very great			Practically zero			(13)
Glass, Crown§	10	85	91	97	1.35	1.38	1.40	
	100	65	74	80	12.5	12.6	12.7	
Glass, Light flint§	10	86	92	97	1.22	1.25	1.28	
	100	66	75	80	11.4	11.5	11.7	

* Corresponds to plain carbon arc.
† Corresponds to W-filament vacuum lamp at 9 lumens per watt.
‡ White light; approximately noon sunlight. § Typical data.

Color Filters for Photometry of Black-Body Sources

Suitable dilutions of stock solutions A and B may be used to produce a color match between two sources which, in the visible spectrum, radiate approximately like black-bodies (19).

Stock A, yellow: 100 g $CoSO_4(NH_4)_2SO_4.6H_2O$ + 0.733 g $K_2Cr_2O_7$ + 10 cm³ HNO_3 (d = 1.05) + H_2O to make 1 l of solution. Stock B, blue: 50 g $NiSO_4(NH_4)_2SO_4.6H_2O$ + 10 g $(NH_2)_4SO_4$ + 55 cm³ NH_4OH (d = 0.90) + H_2O to make 1 l of solution. Stock A is to be diluted with H_2O; stock B with a solution of 10 g $(NH_4)_2SO_4$ in 1000 cm³ H_2O. For transmission, *v.* Figs. 1A, 1A_t, and 1B.

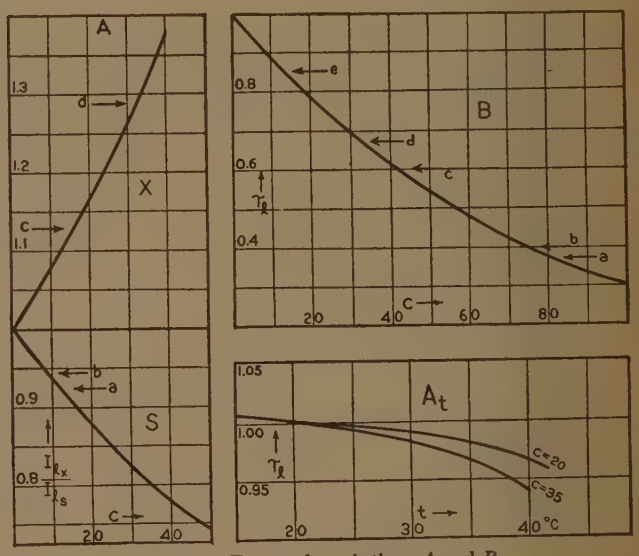

FIG. 1.—Factors for solutions A and B.

Source: Carbon filament lamp at 4 watts per candle. Solution is 1 cm thick. Unit of concentration (C) = 1 cm³ stock per 100 cm³ of solution. C-l [W-l] = carbon [tungsten] filament lamp; w. p. h. c. = watts per horizontal candle; w. p. m. s. c. = watts per mean spherical candle.

A. Multiplication factor for solution A at 20°C. I_{lx} [I_{ls}] = luminous intensity of source x [of standard C-l at 4 w. p. c.]; in section S [X], filter is in front of standard [of source x]. For S, $\tau_l = I_{lx}/I_{ls}$ and $\log_{10}\tau_l = -0.245(0.01C)^{0.9}$; for X, $\tau_l = I_{ls}/I_{lx}$ and $\log_{10}\tau_l = -0.366(0.01C)^{1.05}$. Color match: a = Hefner lamp, b = Pentane lamp, c = W-l at 1.25 w. p. h. c., d = W-l at 0.65 w. p. m. s. c.

A_t. Variation of transmission factor (τ_l) of solution A with temperature. Ordinates are $(\tau_l)^{t°}/(\tau_l)^{20°}$.

B. Transmission factor (τ_l) of solution B at 20°C. τ_l is practically independent of temperature; $\log_{10}\tau_l = -0.539(0.01C)^{1.03}$. Color match: a = W-l at 0.5 w. p. m. s. c., b = W-l at 0.65 w. p. m. s. c., c = W-l at 1.0 w. p. h. c., d = W-l at 1.25 w. p. h. c., e = C-l at 3.1 w. p. h. c.

Diffusing Materials

On transmission through a plate of diffusing material, such as opal glass, light is scattered in all directions; the apparent brightness of the second surface depends on (*a*) the material, its thickness, and the state of its surface; (*b*) the angle of incidence of the light; (*c*) the angle of view, and the relation between the plane of incidence and that of the direction of view.

The first (*a*) is so dependent on small variations in manufacture that only typical data can be given (4, 21, 27); *see* Figs. 2, 3.

In general $\log_{10} \tau_i = ax^b$, where x is the thickness and a and b are constants of the material; for a certain opal glass (12) $a = -0.282$ and $b = 0.80$ if unit of x is 1 mm.

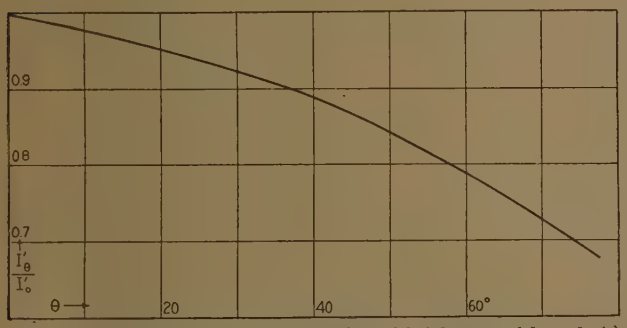

FIG. 2.—Diffuse transmission: Variation of brightness with angle (θ) of view (27).

Opal glass; incidence normal ($\varphi = 0$).

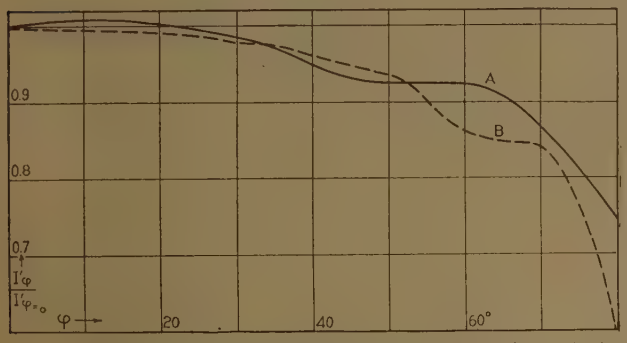

FIG. 3.—Diffuse transmission: Variation of brightness with angle (φ) of incidence (39).

Opal glass; angle of view normal ($\theta = 0$). Curve *A* is for rough (depolished) and *B* is for polished glass.

TABLE 2.—ABSOLUTE INTENSITY OF LIGHT SCATTERED LATERALLY BY DUST-FREE GASES AND LIQUIDS

$I_{i\kappa}[I_{i\beta}]$ = Luminous intensity of incident light [of light scattered at angle β to the incident beam]; v = volume of the gas which participates in the scattering; *V. P.* = pressure of saturated vapor; t_c, P_c = critical temperature and pressure. If $\beta = 90°$, $I_{i\beta} = RvI_{i\kappa}$.

Unit of $R = 1$ cm^{-3}; of $P = 1$ mm of Hg; of $\lambda = 1$ Å $= 10^{-8}$ cm; t is °C

Substance	t	P	λ	R	Lit.
Air, gas	t_R*	760	3030	3.65×10^{-8}	(5)
	t_R*	760	3340	2.70×10^{-8}	(5)
A, gas	27	760	4358	1.34×10^{-8}	(6, 7)
CO_2, liquid	30.5	*V. P.*	5400	2.79×10^{-4}	(3)
	t_c	P_c	5400	9.76×10^{-4}	(3)

* Temperature not stated; probably room temperature.

TABLE 3.—INTENSITY RELATIVE TO AIR, OF LIGHT SCATTERED LATERALLY BY DUST-FREE GASES

(For absolute values, *v.* Table 2; for polarization of scattered light, *v.* Table 4.)

Pressure (P) = *ca.* 1 atm.; room temperature; $\beta = 90°$; S [Sa] = intensity of light scattered by the gas [by air] under same conditions of t and P.

Method and source of light: (*a*) Visual: C-arc (40) for H and $(C_2H_5)_2O$. (*b*) Photographic: Hg-arc (7, 40); sun (11); C-arc (37, 40).

Gas	S/S_a	Lit.	Gas	S/S_a	Lit.
Air	1.00		O_2	0.93*	(7)
A	0.79	(7)	Xe	5.45	(11)
H_2	0.23	(7, 40)	N_2O	3.40	(40)
He	0.017	(37)	CO_2	2.62	(7)
Kr	1.95	(11)	$(C_2H_5)_2O$	26.8	(40)
N_2	1.02*	(7)			

* Adjusted; recorded values are < 1 for both N and O.

TABLE 4.—POLARIZATION OF LIGHT SCATTERED LATERALLY BY DUST-FREE GASES AND VAPORS

(For intensity of scattered light, *v.* Table 3; for variation with t and P, *see* Table 6.)

Pressure (P) = *ca.* 1 atm.; room temperature; $\beta = 90°$; *B. P.* = temperature just above the boiling point; p = % defect in polarization = 100 w/s. Values by different observers may differ in ratio of 2 to 3.

Method and source of light: (*a*) Visual: Sun (8, 9, 10, 16, 26, 29, 30, 33, 34); C-arc (40) for $(C_2H_5)_2O$. (*b*) Photographic: Hg-arc (40); sun (10, 11, 17, 26); tungsten arc (36); C-arc (37, 40).

Gas	p	Lit.
Air	4.3	(10, 30, 36)
A	0.50*	(11, 37)
H_2	3.7	(10, 30, 36)
He	<6.5	(37)
Kr	0.55	(11)
N_2	3.6	(10, 17, 36)
Ne	<1.0	(11)
O_2	8.9	(10, 17, 30, 36)
Xe	0.55	(11)
HCl	1.0*	(34)
H_2S	1.0*	(34)
NO	2.6	(10)
N_2O	15.0	(10, 17, 26, 30, 36)
NH_3	1.0*	(17, 34)
CO	3.4†	(10, 34, 40)
CO_2	11.0	(10, 17, 26, 30, 36)

Vapor	t, °C	p	Lit.
CCl_4, Carbon tetrachloride	*B. P.*	2.5	(16, 29, 40)
CS_2, Carbon disulfide	*B. P.*	15.0	(8, 16, 26, 40)
$CHCl_3$, Chloroform	*B. P.*	3.2	(16, 26, 29, 40)
CH_4, Methane	20	1.5	(9)
CH_4O, Methyl alcohol	*B. P.*	2.7	(16)
C_2N_2, Cyanogen	20	12.0	(40)
C_2H_4, Ethylene	20	3.0	(40)
$C_2H_4O_2$, Methyl formate	*B. P.*	4.6	(16)
C_2H_6, Ethane	20	1.6	(9)
C_2H_6O, Ethyl alcohol	*B. P.*	1.7	(16)
C_3H_6O, Allyl alcohol	*B. P.*	5.2	(16)
C_3H_6O, Acetone	*B. P.*	4.8	(16)
$C_3H_6O_2$, Ethyl formate	*B. P.*	3.3	(16)
$C_3H_6O_2$, Methyl acetate	*B. P.*	4.8	(16)
C_3H_8, Propane	20	1.6	(9)
C_3H_8O, *n*-Propyl alcohol	*B. P.*	2.0	(16)
C_3H_8O, Isopropyl alcohol	*B. P.*	1.9	(16)

* Correction for non-parallelism of incident light reduces p to about 0.8 for HCl, H_2S, and NH_3, and to 0.25 for A; it is suggested that for A, p is actually zero (34).

† By (10) $p = 1.7$ for CO.

TABLE 4.—(*Continued*)

Vapor	t, °C	p	Lit.	Vapor	t, °C	p	Lit.
C_4H_8O, Methyl ethyl ketone	*B. P.*	4.4	(16)	C_5H_{12}, Isopentane	22.5	1.2	(9)
$C_4H_8O_2$, Propyl formate	*B. P.*	3.5	(16)	C_6H_5Br, Bromobenzene	*B. P.*	7.8	(16)
$C_4H_8O_2$, Ethyl acetate	*B. P.*	3.4	(16)	C_6H_5Cl, Chlorobenzene	*B. P.*	7.8	(16)
C_4H_{10}, *n*-Butane	20	1.7	(9)	C_6H_6, Benzene	*B. P.*	6.9	(8, 16, 26, 30, 32, 40)
$C_4H_{10}O$, *n*-Butyl alcohol	*B. P.*	2.8	(16)				
$C_4H_{10}O$, Isobutyl alcohol	*B. P.*	1.8	(16)	C_6H_{12}, Cyclohexane	20	1.1	(33)
$C_4H_{10}O$, Ethyl ether	*B. P.*	3.0	(16, 26, 29, 30, 40)	C_6H_{14}, *n*-Hexane	*B. P.*	3.3	(16)
					28.5	1.5	(9)
C_5H_{10}, 2-Methyl-2-butene	*B. P.*	6.1	(16)	C_7H_8, Toluene	*B. P.*	6.4	(16)
$C_5H_{10}O$, Methyl propyl ketone	*B. P.*	3.2	(16)	C_7H_{16}, Heptane	*B. P.*	3.1	(16)
$C_5H_{10}O_2$, Propyl acetate	*B. P.*	3.2	(16)	C_8H_{10}, *m*-Xylene	*B. P.*	6.7	(16)
C_5H_{12}, *n*-Pentane	*B. P.*	3.0	(16, 30)	C_8H_{18}, Octane	*B. P.*	2.7	(16)
	22.5	1.2	(9)				

TABLE 5.—RELATIVE INTENSITY AND POLARIZATION OF LIGHT SCATTERED LATERALLY BY DUST-FREE LIQUIDS

(For variation with temperature and pressure, *v*. Table 6.)

$\beta = 90°$; S [S_s] = intensity of light scattered by the liquid [by liquid $(C_2H_5)_2O$ at same temperature] W, R, G, B = white, red, green, blue; subscript i [s] indicates color filter is in incident [in scattered] light (if liquid does not fluoresce the value for i = that for s). Temperature: 18°C (8, 18, 22, 23, 24), 30°C (20, 35), 20°C (25), 35°C (29). Method and source of light: (*a*) Visual: Sun (8, 18, 20, 35, 41), C-arc (22), W-arc (23, 24, 25). (*b*) Photographic; Sun (29).

Substance	S/S_s	Lit.	p = % defect in polarization = $100w/s$								
			W	Lit.	W	R_i	R_s	G_i	G_s	B_i	B_s	Lit.
H_2O, Water	0.20	(20, 24, 29)	9.0	(8, 18, 20, 23, 29)	9.6	8.5	11.8	7.9	9.5	14.5	9.9	(20)
SO_2, Sulfur dioxide	1.70	(22)	22.0	(22)								
CCl_4, Carbon tetrachloride	1.10	(20, 29)	9.0	(8, 20, 29)								
CS_2, Carbon bisulfide	14.0	(20, 24, 29)	70	(8, 15, 20, 24, 29, 35)	69	68.5	70			71	73	(20)
$CHCl_3$, Chloroform	1.40	(20, 29)	20.0	(20, 23, 29)								
CH_2Cl_2, Methylene chloride	1.24	(20)	31	(20)								
CH_2O_2, Formic acid	1.22	(20)	55	(20)								
CH_4O, Methyl alcohol*	0.56	(20, 24, 29)	8.0	(20, 22, 29)	8.2	6.0	8.0			12.6	7.4	(20)
$C_2H_4Br_2$, Ethylene bromide	3.42	(20)	61	(20)								
$C_2H_4Cl_2$, Ethylene chloride	1.44	(20)	36	(20)								
C_2H_4O, Acetaldehyde	0.89	(20)	20	(20)	20.0	18.9	19.4			21.6	19.0	(20)
$C_2H_4O_2$, Acetic acid	1.19	(20)	47	(20)	47	47	47			48	48	(20)
$C_2H_4O_2$, Methyl formate	1.09	(20)	28.1	(20)								
C_2H_5Br, Ethyl bromide	1.58	(20)	25.0	(20)								
C_2H_6S, Methyl sulfide	1.22	(20)	12.9	(20)								
C_2H_6O, Ethyl alcohol	0.60	(20, 24, 29)	7.3	(20, 24, 29)	6.8	5.3	7.1			10.5	6.8	(20)
C_3H_5Br, Allyl bromide	3.10	(20)	59	(20)								
C_3H_5Cl, Allyl chloride	1.47	(20)	36	(20)								
C_3H_6O, Allyl alcohol	1.22	(20)	29.3	(20)	29.3	29.6	29.4	34	31	38	37	(20)
C_3H_6O, Acetone†	0.81	(20)	26	(20, 35)								
$C_3H_6O_2$, Propionic acid	1.24	(20)	41	(20)	41	41	42	42	41.5	49	47	(20)
$C_3H_6O_2$, Ethyl formate	1.00	(20)	22.1	(20)	22.1	21.3	21.6			20.7	19.6	(20)
C_3H_7Br, Propyl bromide			25.0	(20)								
C_3H_7Cl, *n*-Propyl chloride	1.34	(20)	16.3	(20)								
C_3H_7Cl, Isopropyl chloride‡	1.38	(20)	16.2	(20)								
C_3H_8O, *n*-Propyl alcohol	0.66	(20, 24)	8.0	(20, 24)	7.6	7.1	9.9			11.0	7.2	(20)
C_3H_8O, Isopropyl alcohol	0.60	(20)	7.2	(20)	7.2	5.0	6.7			10.7	7.2	(20)
$C_4H_6O_3$, Acetic anhydride	1.01	(20)	43	(20)								
C_4H_8O, Methyl ethyl ketone†	0.80	(20)	17.4	(20)	17.4	16.6	18.1			25.5	18.2	(20)
$C_4H_8O_2$, Butyric acid	1.19	(20)	40	(20)	40	36	39	41.5	44	68	55	(20)
$C_4H_8O_2$, Propyl formate	0.94	(20)	21.0	(20)	21.0	21.0	21.1	18.1	20.4	18.6	17.7	(20)
$C_4H_8O_2$, Ethyl acetate	0.95	(20, 22)	23.0	(20, 22)								
C_4H_9Br, Isobutyl bromide			26.4	(20)								
C_4H_9Cl, Isobutyl chloride	1.59	(22)	17.0	(20, 22)								
$C_4H_{10}S$, Ethyl sulfide	1.33	(20)	18.2	(20)								
$C_4H_{10}O$, *n*-Butyl alcohol	0.65	(20)	11.5	(20)	11.5	9.3	11.0			14.9	11.0	(20)
$C_4H_{10}O$, Isobutyl alcohol	0.76	(20, 24)	10.0	(20, 24)	11.2	7.3	11.8			16.3	9.0	(20)
$C_4H_{10}O$, *tert.*-Butyl alcohol	0.69	(20)	6.2	(20)	6.2	4.1	5.8			9.2	5.6	(20)
$C_4H_{10}O$, Ethyl ether	1.00		9.0	(15, 20, 24, 29, 31)	9.1	8.0	9.3	8.3	8.9	10.9	8.8	(20)
C_5H_{10}, 2-Methyl-2-butene	1.54	(20)	25.8	(20)								
$C_5H_{10}O$, Diethyl ketone†	1.06	(20)	36	(20)	36	18.0	36.0			78	24.9	(20)

Substance	S/S_e	Lit.	p = % defect in polarization = $100w/s$							
			W	Lit.	W	R_i	R_e	G_i	G_e	B_i	B_e	Lit.
$C_5H_{10}O$, Methyl propyl ketone			19.6	(20)								
$C_5H_{10}O_2$, Propyl acetate	0.95	(20)	21.7	(20)								
C_5H_{12}, *n*-Pentane	1.25	(20, 41)	7.5	(20, 23)								
C_5H_{12}, Isopentane	1.06	(20)	5.6	(20)								
$C_5H_{12}O$, *dl*-Amyl alcohol	0.74	(20)	11.9	(20)	11.9	9.8	12.5			27.9	10.8	(20)
$C_5H_{12}O$, Isoamyl alcohol	0.84	(24)	9.0	(15)								
C_6H_5Br, Bromobenzene	4.92	(20)	65	(20)								
C_6H_5Cl, Chlorobenzene	4.1	(20, 24)	54.0	(20, 22, 23, 24)	58	57.5	58	61	61	56	55	(20)
$C_6H_5NO_2$, Nitrobenzene	10.5	(20)	70.0	(20, 23, 38)								
C_6H_6, Benzene	3.2	(20, 24, 29, 32)	48.0	(8, 15, 18, 20, 24, 25, 29, 32)	47	47	47	48	48	50	51	(20)
C_6H_7N, Aniline§	3.42	(20)	60	(20)								
$C_6H_{10}O_3$, Propionic anhydride	1.41	(20)	44	(20)								
C_6H_{12}, Cyclohexane	0.87	(24)	8.0	(24)								
C_6H_{14}, Hexane	1.05	(24)	10.0	(20, 24)								
C_7H_5N, Benzonitrile			65.0	(38)								
$C_7H_6Cl_2$, Benzal chloride	3.21	(20)	55	(20)	55	52	55			71	53	(20)
C_7H_7Cl, Benzyl chloride	3.50	(20)	58	(20)	58	56	61			73	54	(20)
$C_7H_7NO_2$, *o*-Nitrotoluene§	9.4	(20)	82	(20)								
$C_7H_7NO_2$, *m*-Nitrotoluene§	9.8	(20)	83	(20)								
C_7H_8, Toluene	3.5	(20, 24, 29)	51.0	(15, 20, 24, 29)	52.5	52.5	52	55	51	57.5	59	(20)
C_7H_8O, Benzyl alcohol	2.93	(20)	65	(20)	65	62	63			67	66	(20)
C_7H_{16}, Heptane	1.00	(20)	11.0	(20, 25)								
C_8H_{10}, Ethylbenzene	3.18	(20)	53	(20)	53	54	53	53	55	53	59	(20)
C_8H_{10}, *o*-Xylene			40	(20)	40	40	38			42	41	(20)
C_8H_{10}, *m*-Xylene	3.87	(20)	57	(20)	57	56	60			64	61	(20)
C_8H_{10}, *p*-Xylene	4.61	(20)	66	(20)	66	66	67			67	68	(20)
C_8H_{10}, *o*-, *m*-, *p*-Xylene‖	3.55	(24)	52.5	(24)								
$C_8H_{16}O_2$, Isobutyl butyrate	1.35	(22)	17.3	(22)								
C_8H_{18}, Octane	0.96	(20)	12.9	(20)								
$C_9H_{10}O_2$, Ethyl benzoate	6.5	(22)	55	(22)								
$C_{10}H_7Cl$, α-Chloronaphthalene	18.2	(22)	78	(22)								
$C_{10}H_8$, Naphthalene	*v.* Table 6											
$SiCl_4$, Silicon tetrachloride	1.13	(20)	5.8	(20)								

* Liquid became dark brown. † Showed tendency to decompose. ‡ Background not perfect. § Not quite free from dust particles. ‖ Mixture of xylenes

TABLE 6.—INTENSITY AND POLARIZATION OF LIGHT SCATTERED BY DUST-FREE LIQUIDS AND VAPORS: VARIATION WITH TEMPERATURE AND PRESSURE

Sat. vap. = saturated vapor; Unsat. = unsaturated vapor; G = vapor above critical temperature; G_d = G at constant density, d; $V.\ P.$ = pressure of saturated vapor; S_t, $[S_0]$, $[S_{e35}]$ = intensity of light scattered by the gas at t,°C, P = 1 atm. [by the gas at 0°C and P = 1 atm.], [by liquid $(C_2H_5)_2O$ at 35°C]; p = % defect in polarization. Unit of P = 1 atm.

CO_2 (28)

P	S_t/S_0	t, °C	S_t/S_0		P	S_t/S_0	p
G, t = 35°C		G_d, d = 0.320			Unsat., t = 30°C		
61	290	40	1 620		68	1 078	
67	680	50	1 410		Sat. vap.		
72	1 170	Unsat., t = 30°C			t, °C	S_t/S_0	p
77.5	3 200	P	S_t/S_0	p	5	102	
81	4 230	15	22		10	195	
87	1 750	20	33		15	347	5.8
91	1 430	30	54	9	20	567	4
		40	83	8	24	1 030	
G_d, d = 0.320		50	140	6	25	1 190	3
t, °C	S_t/S_0	55	197		26	1 890	
32	4 550	60	307	4.5	28	3 560	
35	2 730	65	665	4	30	8 000	1.5

CO_2.—(*Continued*)

Liquid

t, °C	P	S_t/S_0	p
5	*V. P.*	360	
10	*V. P.*	480	14
15	*V. P.*	680	10
15	51	663	
15	68	522	
15	76	470	
15	82	428	
20	*V. P.*	990	8
20	80		10
20	92		13
23	*V. P.*	1 280	
25	*V. P.*	1 880	5
25	*V. P.*	2 100	
25	68	1 650	
25	74	1 200	
25	83	778	
25	90		9
25	92	600	
27	*V. P.*	2 950	3
29	*V. P.*	6 200	3
30	*V. P.*	11 000	
30.5	*V. P.*	22 500	
30.5	72.5	5 480	
30.5	76.5	2 610	
30.5	84.0	1 097	
30.5	86.5	940	
31	*V. P.*	35 000	

$C_4H_{10}O$, Ethyl ether (31)

t, °C	S_t/S_{e35}
G	
194	378
196	172
198	126
200	84
202	64
212.5	27
217	21

Sat. vap.*

t, °C	S_t/S_{e35}
33	0.038
54	0.075
75	0.150
91	0.22
108	0.45
123.5	0.71
144.5	1.31
164	2.7
170.5	3.9
179.2	9.1
183.5	13.0

$C_4H_{10}O$.—(*Cont'd*)

Sat. vap.*

t, °C	S_t/S_{e35}
186.5	21
190	42
191	63

Liquid

t, °C	S_t/S_{e35}	p
33	1.00	8
61	1.23	8
80	1.85	7
91	1.90	
104	2.3	7
125	3.0	7.5
139	3.8	5
145	4.9	3
153	6.3	1.7
170	12.0	1.7
179	22	
185	38	1.3
190.5	82	1.3

* From t = 160 to 200°C, p varies from 1.3 to 1.0; no change in passing through critical temperature.

C_5H_{12}, *n*-Pentane (41)

t, °C	S_t/S_{e35}	p
	G	
200	48.5	
203	30.8	
210	20.8	
214	15.2	
	Sat. vap.	
87	0.235	
125.2	0.73	
137	1.20	
145	1.95	2.5
149	2.10	
154	2.42	
155.4	2.66	
167	3.90	2.0
172	5.88	
183	13.4	1.5
187	17.8	
189	22.1	
190.5	23.3	
193	30.8	
196	70.8	1.5

C_5H_{12}.—(*Cont'd*)

t, °C	S_t/S_{e35}	p
	Liquid	
36.5	1.61	7.2
80		7.2
86.6	2.84	6.7
103.8	3.40	
117.0	4.25	5.2
128.0	5.36	5.2
138.0	6.37	
148.6	8.18	1.7
156.8	9.10	1.5
173		1.5

C_6H_6, Benzene
Sat. vap. (32)

35		7.2
100		6.2
182	0.95	3.5
204	1.56	3.4
228	3.00	2.5
247	4.9	2.0
267	11.9	1.5
280		0.9

C_6H_6.—(*Cont'd*)

t, °C	S_t/S_{e35}	p
	Liquid (32)	
35	3.2	43
125	3.67	32
182	5.48	19
205	7.21	14
228	11.0	9.5
268	20.5	3.0
283	102	2.8

t, °C	S_t/S_{20}	p
	Liquid (25)	
0		49†
5		48‡
10		48
20	1.00	49
100	1.33	39
200	2.40	15.4
250	6.0	6.1
260	10.7	4.5
270	19.4	2.5
280	62.0	1.5

†Under-cooled. ‡ M.P.

C_7H_{16}, Heptane

t, °C	S_t/S_{20}	p
	Liquid (25)	
20	1.00	12.7
100	1.30	10.0
200	3.97	3.8
225	6.8	2.6

C_7H_{16}.—(*Cont'd*)

t, °C	S_t/S_{20}	p
	Liquid (25)	
240	10.1	2.0
250	13.4	1.7
260§	16.8	1.65
270§	28.1	1.55

§ At critical temperature S_t/S_{20} is very great.

$C_{10}H_8$, Naphthalene

t, °C	S_t/S_{80}	p
	Liquid (25)	
80	1.00	71.0
200	1.04	63.5
300	1.30	41.0

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SPECTRAL ABSORPTION OF LIGHT AND HEAT BY PURE INORGANIC SUBSTANCES AND MISCELLANEOUS MATERIALS (NONMETALS)

JEAN BECQUEREL AND J. ROSSIGNOL

Order of Substances.—Atmospheric air, elementary substances, pure inorganic compounds, minerals of variable composition.

ABSORPTION OF ATMOSPHERIC AIR

w = equivalent thickness of liquid H_2O in a column of air 117 m long (P = 1 atm., t < 40°C) = volume of liquid H_2O obtained by condensing the H_2O vapor contained in a column of air of unit sectional area and 117 m long. O = opacity of the atmosphere (source of light at zenith) = I_i/I_0; $I_i[I_0]$ = intensity of radiation beyond atmosphere [at surface of earth]. $I = I_0e^{-kl(10)^n}$; l = length of path in which intensity is reduced from I_0 to I. All I's refer to radiant energy, not to its visibility.

Unit of $k(10)^n$ = 1 cm^{-1}; of l = 1 cm; of w = 1 cm; of λ = 1μ = 10^{4}Å = 10^{-4} cm.

λ	k
Dry air (12), w = 0, n = −3	
0.186	4.82

Moist air (7), n = −5

w	0.008	0.082
λ	k	k
1.3 to 1.75	0.54	1.7
1.75 to 2.2	1.25	2.9
2.2 to 3.2	2.3	4.5

w	0.008	0.082
λ	k	k
3.2 to 4.0	2.1	3.95
4.0 to 4.9	3.3	5.9
4.9 to 5.4	1.7	4.7
5.4 to 5.9	5.4	16
5.9 to 6.4	8.7	30
6.4 to 7.0	9.8	30
7.0 to 8.0	2.5	8.3

Moist air (7), n = −5

w	0.003	0.03	0.3	3.0
λ	k	k	k	k
3 to 4	0.9	3.05	5.9	12
4 to 5	1.4	5.1	10.3	26
5 to 6	1.5	4.8	9.2	26
6 to 7	5.1	16	26	>40
7 to 8	1.2	4.7	16	>40
8 to 9	< 0.1	0.17	4.4	5.9
9 to 10	< 0.1	< 0.1	< 0.1	1.4
10 to 11	< 0.1	0.17	0.44	4.4
11 to 12	< 0.1	< 0.1	0.35	0.9
12 to 13	< 0.1	< 0.1	1.2	1.9
13 to 16	>40	>40	>40	>40
16 to 20	20	>40	>40	>40
20 to 30	10(?)	14(?)	20(?)	>40
30 to 40	>40(?)	>40(?)	>40(?)	>40
40 to 50	>40	>40	>40	>40

Opacity of atmosphere* (6)

λ	$\text{Log}_{10} O$	λ	$\text{Log}_{10} O$	λ	$\text{Log}_{10} O$
0.2898	6.36	0.2931	4.36	0.2997	2.22
.2906	5.78	.2936	4.12	.3022	1.77
.2912	5.39	.2946	3.73	.3052	1.40
.2917	5.08	.2956	3.33	.3104	0.99
.2922	4.82	.2963	3.10	.3143	0.84

* Average conditions, no clouds, value of w is not indicated.

Absorption of Pure Non-Metallic Inorganic Substances and Minerals

$I = I_0 e^{-kl(10)^n}$, l = length of path in which intensity is reduced from I_0 to I; I and I_0 refer to radiant energy, not to its visibility; d = density. For metals, *v.* p. 248.

Unit of $k(10)^n$ = 1 cm^{-1}; of l = 1 cm; of P = 1 mm of Hg; of d = 1 g cm^{-3}; of $\lambda = 1\mu = 10^4$Å $= 10^{-4}$ cm; t is °C.

Br (24), t = 16°, P = 66, n = −2

λ	k
0.356	10.6±0.1
.3641	22.4±0.2
.3713	38.9±0.4
.3838	75.3±0.8
.3900	98 ±1
.4009	129 ±1
.4070	136 ±1
.421	135 ±1
.433	128 ±1
.449	112 ±1
.487	76 ±4
.510	57 ±3
.526	38 ±2
.546	23 ±1
.572	12.1±0.6
.608	3.1±0.2

t = 320°,

0.354	21.3±0.4
.377	65 ±1
.406	115 ±2
.428	122 ±2
.439	115 ±2
.471	85 ±2

Br.—(*Cont'd*)

λ	k
0.510	51 ±1
.557	19.6±0.4

t = 620°

0.344	18.3±0.4
.358	37.6±0.8
.379	74 ±1
.395	97 ±2
.420	113 ±2
.433	113 ±2
.459	97 ±2
.484	74 ±1
.530	37.9±0.8
.577	16.3±0.3

C, Diamond (22)*

0.226	1477
.2315	678
.255	74±1
.275	59±1
.300	43±1
.320	32±1
.350	21±2
.380	15±1
.400	12

C.—(*Continued*)

λ	k
0.430	11
.550	<1
.600	3

C, Graphite (37)†

0.430	1455±25
.450	1410±25
.500	1305±25
.550	1225±20
.600	1155±20
.650	1110±15
.700	1070±15

C, Amorphous (30)†

0.430	198.0±1.0
.450	188.0±1.0
.480	174.5±1.0
.500	166.0±1.0
.530	155.5±1.5
.550	149.5±1.5
.580	141.5±1.0
.600	137.0±1.0
.630	131.5±0.5

*n = −2. †n = +3.

Cl, t = 0°, P = 760, n = −2

λ	k (21)	k (10)	k (24)	λ	k (21)	k (10)	k (24)
0.226	62			0.338			568±11
.230	62			.340	527		
.235	62			.346			529±10
.245	43			.350	477		
.250	43			.3525			456± 9
.254		2.5		.3593			366± 7
.255	50			.360	422		
.260	60			.365			280± 6
.265		12.8		.366		284	
.270	80			.370	370		
.275	93			.373			192± 4
.280	123	77.1		.380	212		
.285	157			.381			130± 2
.289		74.8		.385	158		
.290	187			.390	183		
.295	211			.405	277	41.6	
.297		278		.410	211		
.300	300			.411			3.7±0.1
.303		367		.435	117		
.310	415			.436		17.1	
.313		571		.472		4.2	
.3142			129± 2	.480		2.4	
.3192			225± 4	.496		1.05	
.320	508			.509		0.47	
.321			315± 6	.545	61		
.3238			445± 9	.546		0.018	
.327			529±10	.579		0.003	
.330	560			.580	82		
.331			565±11	.614		0.51	
.334		684		.643		0.41	

I, Solid (17), n = +3

λ	k
0.325	318
.360	462
.400	466
.440	437
.470	384
.510	300
.590	120

I, Gas (32), n = −2

t	48°	88°	400°
10 000d	0.254	2.5	2.5
λ	k	k	k
0.440	0.8		
.445	4.0		
.450	6.5		19
.455	9		23
.460	10	13	27
.465	12	17	32
.470	13	22	37
.475	15	29	45
.480	16	40	55
.485	17	54	64
.490	19	64	68
.495	20	71	71
.500	21	75	72
.505	20	77	71
.510	19	76	68
.515	16	68	60
.520	14	52	48
.525	13	42	38
.530	13	36	35
.535	13	32	34
.540	14	29	34
.545	14	27	33
.550	14	26	31
.555	15	25	29
.560	15	24	26
.565	14	23	23
.570	13	22	21
.575	11	21	20
.580	9	20	19
.585	8	18	20
.590	7	16	20
.595		14	

N_2 (12), t = 0°, P = 760, n = −5

λ	k
0.186	109

O_2 (12), t = 0° P = 760, n = −3

λ	k
0.186	20.6
0.193	3.35

O_2, P = 760 (t + 273)/273, n = 0 (35)

t	1220°	1400°
λ	k	k
0.210	0.33	0.73
.220	0.26	0.50
.230	0.19	0.32
.239	0.13	0.22
.254	0.06	0.13
t	1580°	1760°
λ	k	k
0.210	>4.5	>4.5
.220	0.92	1.77
.230	0.54	0.97
.239	0.37	0.67
.254	0.21	0.42

O_3, Ozone, t = 0°, P = 1, n = 0

λ	k (19)	k (13)	k (5)
0.193	26.9		
.200	17.9		
.210	26.4		
.220	44.3		
.230	112		115
.240	241	260	219
.250	284	374	276
.254		430	
.260	291		276
.265		341	
.270	267	174	209
.280	169	112	106
.290	89	56	38
.300	69.8	18	10.6
.310			2.83
.320			0.81
.330			0.21
.340			0.06

S, Gas (11), t = 450°, d = 67 × 10^{-6}, n = −2

λ	k
0.435	27
.460	20
.500	15
.550	7
.610	<0.5

Se, Vitreous, n = +3

λ	k (36)	k (17)
0.260		613
.275		611
.300		652
.325		580
.360		480
.400	726	380
.415	660	
.425	594	
.440	525	300
.470	460	252
.490	382	
.510		203
.515	273	
.550	176	
.590	95.5	170
.640	47.1	
.670		84
.710	21.4	
.760	10.1	

Se, Gas (11), t = 700°C, d = 10.9 × 10^{-5}, n = −2

λ	k
0.435	43
.450	39
.510	23
.525	19
.580	<0.5

H_2O, Gas (3), t = 0°, P = 760, n = −3

1.35	4.6
1.37	8.7

H_2O.—(*Cont'd*)

λ	k
1.404	19.3
1.45	11.4
1.50	4.2
1.80	3.7
1.85	18.7
1.885	25.8
1.935	18.8
1.97	12.0
2.0	3.6
2.55	25.8
2.585	64.4
2.618	90
2.65	59

H_2O, Liquid (12), n = −2

λ	k
0.186	68.8
.193	16.6
.200	9.0
.210	6.1
.220	5.7
.230	3.4
.240	3.2
.260	2.5
.300	1.5

n = −3

λ	k (1)	k (4)	k (2)
0.415		0.35	
.420		0.32	
.430*		0.23	
.440		0.16	
.450	0.20	0.12	
.460		0.11	
.470		0.12	
.480	0.20	0.13	
.490		0.14	0.02
.500	0.20	0.15	
.510	0.22	0.16	
.520	0.18	0.18	0.02
.530	0.08	0.19	0.03
.540*	0.09	0.21	0.11
.550	0.36	0.23	0.26
.560	0.30	0.27	0.40
.570	0.20	0.33	0.43
.580*	0.26	0.42	0.50
.590	0.78	0.70	0.89
.600	1.60	1.07	1.65
.610	1.90	1.18	2.20
.620	2.12	1.24	2.40
.630	2.24	1.30	2.50
.640	2.35	1.37	2.75
.650	2.50	1.48	3.05
.660	2.80	1.62	3.25
.670	3.00	1.83	
.680	3.40	2.10	
.690	4.00	2.50	
.700	5.50	3.00	
.710	7.90	3.90	
.720	11.5	4.70	
.730	17.5	5.70	
.740	23.0		
.75	24.1		
.80	20.4	(3)	
.85		69	
.90		161	
.95		311	
.995	416	472	
1.05		368	

*Liquid H_2O, (16) n = −3.

λ	0.4358	0.5461	0.5780
k	0.12	0.34	0.64

H_2O.—(*Cont'd*)

$n = 0$

λ	k(1)	k(3)
1.05		0.368
1.085		0.333
1.095	0.188	
1.13		0.60
1.17		1.12
1.21		1.30
1.243	1.22	
1.25		1.24
1.281	1.17	
1.30		1.48
1.35		2.14
1.40		3.05
1.45		20.1
1.475		29.9
1.50	38.4	26.4
1.56		15.0
1.60		9.2
1.677		5.2
1.708	11.4	
1.75		7.5
1.85		12.7
1.90		31.5
1.95		86
1.956	123	
1.97		104
2.00		70
2.08		35.6
2.10		31.6
2.147	27.8	
2.15		24.7
2.237		19.6
2.30		25.9
2.35		33.0
2.40		40.3

$n = +2$

λ	k(1)	k(9)
2.6		5.32
2.8		22.4
3.0		73.3
3.02	27.3	
3.2		66.4
3.4		14.4
3.6		4.9
3.93	2.04	
4.5		4.47
4.70	5.45	
5.27	3.08	
5.42	3.42	
5.47	3.35	
5.8		9.1
6.0		21.4
6.09	25.3	
6.2		20.0
6.5		10.3
6.73	8.7	
6.765	8.8	
6.92	8.2	
6.955	8.3	
7.0		8.9
7.11	8.2	
7.275	8.45	
7.41	7.9	
7.44	8.1	
7.49	8.0	
7.545	8.1	
7.65	7.65	
7.70	7.85	
7.83	7.65	
7.88	7.75	
7.94	6.9	
8.0		7.55
8.065	7.85	
8.13	7.65	
8.16	7.85	
8.22	7.15	
8.28	7.65	
8.38	6.95	
8.43	7.55	
8.49	7.25	
9.0		7.0
10.0		7.05

H_2O.—(*Cont'd*)

λ	k(1)	k(9)
11.0		12.0
12.0		25.9
13.0		28.9
15.0		35.7
18.0		29.9
	(25)	
24	>0.46	
52	>0.46	
61	>0.46	
		(20)
108		4.23
314		2.42

HBr, Gas (33); *cf.* (38)
$t = 0°$, $P = 760$, $n = -3$

λ	k
0.207	44.4
.253	3.20

HI, Gas (34); *cf.* (38)
$t = 0°$
$P = 760$, $n = -3$

0.207	62.2
.253	29.0

SO_2, Gas (8), $t = 0°$, $P = 760$, $n = 0$

0.220	57
.2225	18.5
.280	32
.285	35.5
.290	39.5
.295	42.5
.300	41
.305	34
.310	20
.315	6.3
.320	4.0

NO, Gas (12), $t = 0°$, $P = 760$, $n = -3$

0.200	142.2
.210	95.1
.220	84.1
.230	52.1
.240	24.0
.250	3.18
.300	0.80

CO_2, Gas (12), $t = 0°$, $P = 760$, $n = -3$

0.186	7.64
.193	2.13
.200	0.95

$n = -3$ (29)

1.96	0.3
2.12	0.3
2.28	0.03
2.40	1.7
2.50	5.7
2.60	11.5
2.70	13.4
2.80	11.4
2.90	6.5
3.00	2.7
3.10	1.1
3.20 }	< 0.01
3.80 }	
3.90	1.3
4.0	4.1

CO_2—(*Cont'd*)

λ	k
4.10	12.0
4.20	33.5
4.25	50
4.30	61
4.33	63
4.35	60
4.40	38
4.45	27
4.50	20
4.60	11.2
4.69	1.2

CS_2, Liquid (25), $n = 0$

24	5.1
52	0.20
61	0.30

SiO_2, *v.* Vol. VI

AgCl (25), $n = 0$

24	4.8
52	>27
61	>27

AgBr, Fused (31), $n = +3$

0.360	6.7
.370	5.0
.380	3.8
.390	2.79
.400	2.00
.410	1.38
.420	0.90
.430	0.60
.440	0.41
.450	0.27

AgI (28), $n = +3$

λ	k
0.215	85.3 ± 1.9
.220	88.0 ± 2.0
.225	87.7 ± 2.0
.230	88.5 ± 2.0
.235	88.8 ± 2.0
.240	96.3 ± 2.1
.245	99.5 ± 2.1
.250	102 ± 2
.255	104 ± 2
.260	113 ± 2
.265	138 ± 3
.270	276 ± 6
.2712	282 ± 6
.275	259 ± 5
.280	235 ± 5
.285	220 ± 4
.290	208 ± 4
.295	198 ± 4
.300	188 ± 4
.305	179 ± 4
.310	171 ± 4
.315	167 ± 4
.3191	167 ± 4
.320	167 ± 4
.325	165 ± 4
.330	158 ± 3
.335	144 ± 3
.340	124 ± 3
.345	117 ± 2

AgI.—(*Cont'd*)

λ	k
0.350	111 ± 2
.355	104 ± 2
.360	101 ± 2
.365	98 ± 2
.370	95 ± 2
.375	93 ± 2
.380	90 ± 2
.385	88 ± 2
.390	87 ± 2
.395	86 ± 2
.400	85 ± 2
.405	85 ± 2
.410	88 ± 2
.415	101 ± 2
.420	128 ± 3
.4227	138 ± 3
.425	117 ± 2
.430	33 ±10
.435	10 ± 3
.440	5.1± 1.5
.445	3.1± 1.0
.450	1.1± 0.3

Fe_3O_4, Magnetite (14), $n = +3$

λ	k
0.440	242
.460	222
.480	201
.500	183
.520	169
.540	158
.560	150
.580	145
.600	138
.620	133
.640	126
.660	118
.680	109
.700	98

$Fe_2O_3.CuO$, Cuproferrite (14), $n = +3$

0.440	270
.460	230
.480	200
.500	179
.520	162
.540	145
.560	118
.580	90
.600	80
.620	72
.640	64
.660	55
.680	47
.700	38

CaF_2, Fluorite
$n = 0$ (23)

0.186	0.22

$n = 0$ (26)

6	<0.01
8	0.17
9	0.61
10	1.8
11	4.6
12	>7

CaF_2.—(*Cont'd*)

λ	k
$n = 0$ (25)	
24	>8.5
52	5.7
61	5.02

$CaCO_3$, Calcite
$n = 0$ (23)

0.215	3.36
.230	1.25
.240	0.58
.250	0.40
.260	0.29
.270	0.20
.280	0.16

k_o†, $n = 0$ (18)

1.02	0.00
1.25	0.00
1.45	0.00
1.72	0.03
2.07	0.13
2.11	0.74
2.30	1.92
2.44	3.00
2.53	1.92
2.60	1.21
2.65	1.74
2.74	2.36
2.83	1.32
2.90	0.70
2.95	1.80
3.04	4.71
3.30	22.7
3.47	19.4
3.62	9.6
3.80	18.6
3.98	∞
4.35	6.6
4.52	14.3
4.66	11.6
4.83	6.1
5.25	8.0

k_e†, $n = 0$ (18)

2.49	0.14
2.87	0.08
3.00	0.43
3.28	1.32
3.38	0.89
3.59	1.79
3.76	2.04
3.90	1.17
4.02	0.89
4.41	1.07
4.67	2.40
4.91	1.25
5.04	2.13
5.34	4.41
5.50	12.8

†k_o for ordinary and k_e for extraordinary ray.

NaCl, Rock salt
$n = 0$ (23)

0.186	0.36
.210	0.26
.231	0.15
.280	0.046

NaCl.—(*Cont'd*)

λ	k
$n = 0$ (27)	
6 to 8	<0.001
9 to 11	0.005
12	0.007
13	0.024
14	0.071
15	0.167
16	0.41
17	0.66
18	1.29
19	2.34
20.7	5.1
$n = 0$ (25)	
24	10.7
52	>16
61	>16

KCl, Sylvite
$n = 0$ (27)

10	0.012
11	0.010
12	0.005
13	0.005
14	0.025
15	0.047
16	0.066
17	0.081
18	0.148
19	0.277
20.7	0.535
24	1.86

Biotite (15), $n = 0$, $t = 25°$

1.52	42.0
1.82	19.0
2.25	8.1
2.76	6.8
2.91	6.2
2.96	6.1
3.0	4.7
3.04	4.6
3.12	4.2
3.22	3.4
3.85	3.6
4.06	3.8
$n = 0$, $t = 250°$	
1.50	63
1.80	42
2.21	34
2.72	22
2.92	19
3.0	17
3.19	16
3.4	13
3.6	12
3.8	10
4.01	11

Mica
$n = +2$ (25)

24	1.8
52	3.2
61	3.0

$n = +2$ (20)

108	3.3
314	1.1

LITERATURE

(For a key to the periodicals see end of volume)

(1) Aschkinass, *8*, **55**: 401; 95. (2) d'Aufsess, *8*, **13**: 678; 04. (3) Dreisch, *96*, **30**: 200; 24. (4) Ewan, *3*, **33**: 317; 92. (5) Fabry and Buisson, *34*, **156**: 782; 13. (6) Fabry and Buisson, *51*, **2**: 197; 21. *21*, **54**: 297; 21. (7) Fowle, *302*, **68**: No. 8; 17. (8) Garrett, *3*, **31**: 505; 16. (9) Goldhammer, *Dispersion und Absorption des Lichtes*. Leipzig, Teubner, 1913.
(10) Halban and Siedentopf, *7*, **103**: 71; 22. (11) Koenigsberger and Küpferer, *8*, **37**: 601; 12. (12*) Kreusler, *8*, **6**: 412: 01. (13) Krüger and Moeller, *63*, **13**: 729; 12. (14) Loria and Zakrzewski, *180*, **1910A**: 278. *10*, **1**: 93; 10. (15) Martin, *5*, **96**: 185; 19. (16) Martin, *50*, **26**: 471; 22. (17) Meier, *8*, **31**: 1017; 10. (18) Merritt, *2*, **2**: 424; 95. (19) Meyer, *8*, **12**: 849; 03.
(20) Owen, *121*, **68**: 504; 12. (21) Peskov, *53*, **47**: 918; 15. (22) Peter, *96*, **15**: 358; 23. (23) Pflüger, *63*, **5**: 215; 04. (24) Ribaud, *6*, **12**: 107; 19. (25) Rubens and Aschkinass, *8*, **65**: 241; 98. (26) Rubens and Nichols, *2*, **4**: 314; 97. (27) Rubens and Nichols, *2*, **5**: 98; 97. (28) Schell, *8*, **35**: 695; 11. (29) Schmidt, *8*, **42**: 415; 13.
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* Errors in computation have been corrected by Becquerel and Rossignol.

SPECTRAL FILTERS

K. S. Gibson

The filters here considered cover the spectral regions commonly designated as ultra-violet (UV), visible (v), and infra-red (IR). The numerical data are based on quantitative measurements, but, owing to the variability of much of the material or to the insufficiency of the details given by the authors, they are, in general, to be considered as illustrative only. As a rule, only such glasses, crystalline material, and simple, well-known substances as have a relatively sharp transition between the regions of free transmission and of strong absorption are noted. Many of these filters, especially those having selective transmission between $\lambda = 0.3\mu$ and 0.7μ, can be practically duplicated by means of dyes and other solutions.

Filters

Spectral filters may conveniently be divided into three classes:

Class 1.—Strong absorption if λ is less than a certain value, λ_c, and free transmission over a wide adjacent range where $\lambda > \lambda_c$.

Radiation in range $0.002\mu < \lambda < 0.12\mu$ is not transmitted by any solid or liquid; of ordinary gases, H_2 is the most and O_2 is the least transparent in this region (31). The UV-limit of transmission of air is near that of H_2O (λ_c of W_1, *ca.* $\lambda = 0.17\mu$) (31). Curves similar to those of Fig. 1 may be obtained between 0.2μ and 0.35μ by use of organic liquids (1, 2, 47), between 0.3μ and 0.7μ by use of solutions or of dyed films of gelatin (15), and in IR (4, 43, 46) by use of thin layers of lampblack or various thicknesses of black paper or cardboard.

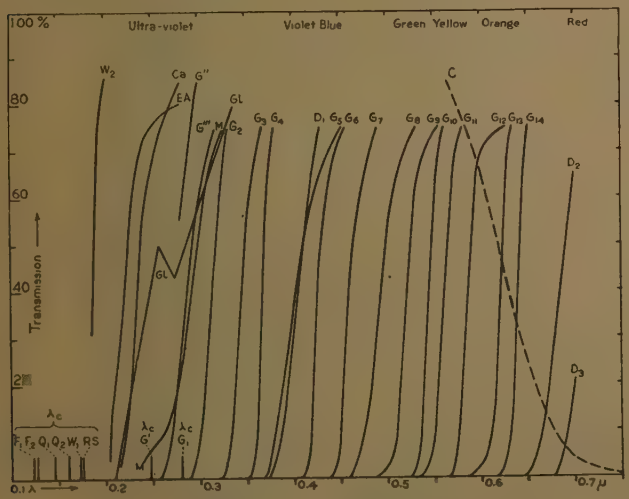


Fig. 1.—Filters of Class 1: Transmission near λ_c.

For descriptions of filters, *see* Table 1; C is of Class 2. For F_1, F_2, Q_1, Q_2, W_1, RS, G′ and G_1, only value of λ_c is indicated; curves for C, Ca, EA, G″, Gl and W_2 have been corrected for surface and window losses (reflection and absorption), other curves are uncorrected. $0.1\mu = 10^{-5}$ cm = 1000 Å.

Class 2.—Strong absorption over wide region in which λ is greater than λ_c, and free transmission over a wide adjacent range for which $\lambda < \lambda_c$.

For the substances considered here, the long wave-length boundary of the absorption lies far in the IR, but transmission at still greater values of λ may be of much importance. For summary of such data, and bibliography to 1921, *see* (46). Crystalline SiO_2 is notably transparent if $\lambda > 50\mu$; if sufficiently thin, many substances transmit if $\lambda >$ *ca.* 100μ, and there is considerable transmission through 1 mm of CaF_2, KCl, NaCl, and amorphous SiO_2, but there seems to be no transmission through this thickness of H_2O or of glass.

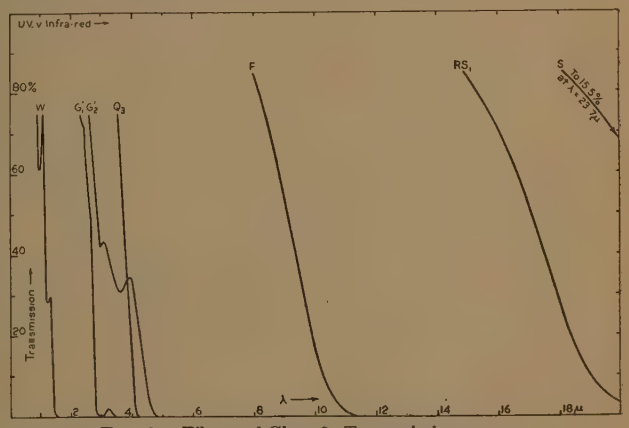


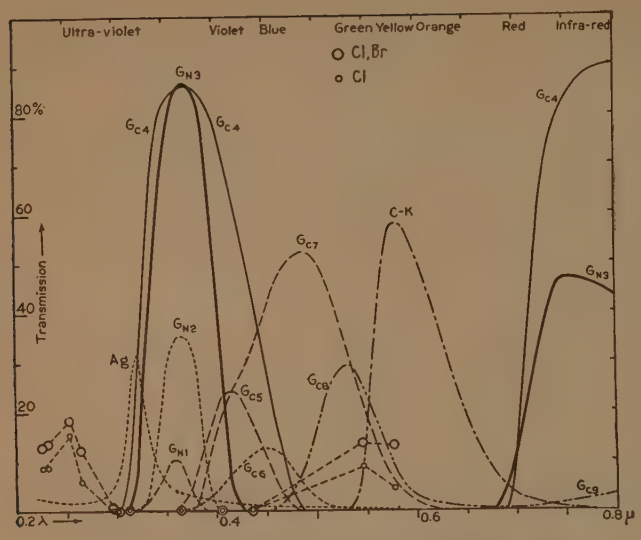
Fig. 2.—Filters of Class 2: Transmission near λ_c.

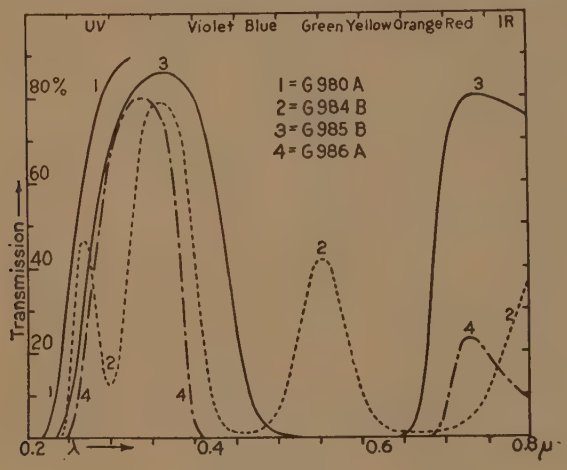
See also C of Fig. 1. For description of filters, *see* Table 1. Curves for F, RS, and S have been corrected for reflection at surfaces, others are uncorrected. $1\mu = 10^{-4}$ cm = 10 000 Å.

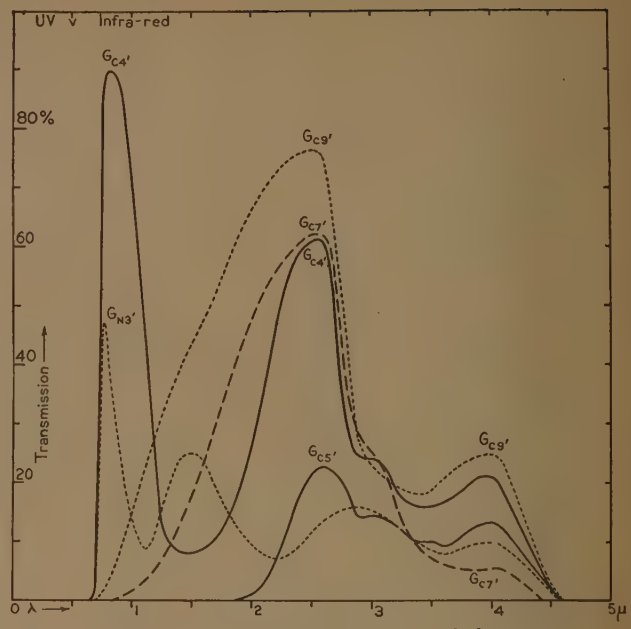
Aqueous (H_2O) solutions of Cu salts completely absorb the IR while freely transmitting the visible spectrum (*cf.* C, Fig. 1); at least 2 cm of the solution should be used (6, 19). For glasses which visually approximate filter C, *see* (16, 20, 22); they all transmit some IR (11, 12). For isolating the region $\lambda < 0.3\mu$, *see* Class 3.

Class 3.—Strong absorption except over certain narrow regions of the spectrum.

In Figs. 3, 4 and 5 are shown the transmissions of certain filters of this class. By a suitable choice of these filters, assisted by those of classes 1 and 2 as may be necessary, it is possible to isolate any one of many narrow spectral regions (19). No known filter transmits only the region $\lambda < 0.3\mu$; the best consists of quartz (SiO_2) cells filled with Cl and Br gas (37); *see* Fig. 3. For transmission of Cl, *see also* (24, 36), of Br (49). Aqueous solutions of acetone (C_3H_6O) (1), of *p*-nitrosodimethylaniline ($C_8H_{10}N_2O$) (37, 45), etc., may assist in isolating the UV, especially when presence of radiation at $\lambda > 0.5\mu$ can be ignored, as in usual photographic work. *See also* Fig. 4 and Special Filters, 4.







FIGS. 3, 4, 5.—Transmission of filters of Class 3.
For description of filters, *see* Table 1.

Special Filters

Filters, for isolating or for removing certain radiations emitted by the source being used, are especially convenient for the following purposes (*see also* Class 3, *supra*):

1. *Eye Protection.*—The cornea may be seriously injured by even a short exposure to UV at $\lambda \gtrsim 0.31\mu$. When exposed to the quartz Hg-arc, unscreened metal arc or spark, or other source which is intense in this region, the eyes should be protected by a filter which absorbs completely all radiations of $\lambda < 0.35\mu$, such as G_4, D_1, etc. (Fig. 1). Radiations of greater λ do not damage the eye unless so intense as to cause discomfort. Glasses are available for reducing the brightness and for absorbing most of the IR (**7, 11, 20**) (*see also* 5*f*).

2. *Trichromatic Photometry.*—The three filters typified by G_{14} (red), G_{C_8} (green), and G_{C_5} or G_{C_4} (blue) form a set which is usually satisfactory; *see also* (**17**).

3. *Elimination of Stray Light.*—In spectrophotometric work at $\lambda < 0.5\mu$ or $\lambda > 0.65\mu$, stray light may introduce error (**18**). For work in blue and violet it may be eliminated by filters of type G_{C_4}, in red by G_{14}, and in far red by $G_{C_4} + G_{14}$, by D_2, or by D_3.

4. *Isolation of Certain Spectral Regions.*—Extra-focal methods assist in isolation in UV (**10**) and IR (**43, 46**). Some of UV can be isolated from all other radiation by G_{N_1}, G_{N_2}, or Ag; most of v by G_6 + C, *see also* (**25**); all of v and UV to λ = *ca.* 0.3μ by C; much of IR, either with or without v, by filters of Class 1 (Fig. 1). For isolation of $\lambda < 0.3\mu$, *see* text for Class 3; of $0.7\mu < \lambda < 1.5\mu$, use W (or Gl) + D_3, or W (or Gl) + G_{C_4} (or G_{N_3}) + a red glass, of $1\mu < \lambda < 3\mu$, use G_{14} (or D_2) + G_1' + G_{C_7}'; of $2\mu < \lambda < 3\mu$, use G_{14} (or D_2) + G_1' + G_{C_9}'. Certain regions (residual rays) between $\lambda = 8\mu$ and $\lambda = 152\mu$ may be isolated by multiple reflection from SiO_2 (λ = 8 to 9μ), TlI ($\lambda = 152\mu$), and other substances (**3, 4, 46**); (*see also* p. 261).

5. *Isolation or Removal of Certain Lines from a Line Spectrum.*—[*See also* (**32**).] In combination with the following, filters of Classes 1 and 2 may be used to absorb the UV and IR.

(*a*) *Hg-arc in SiO_2.*—$\lambda = 0.578\mu$ is absorbed and $\lambda = 0.546\mu$ is transmitted by filter X. The visible lines (0.578, 0.546, 0.436, 0.405μ) may be readily isolated from one another by glasses (**19, 22**), solutions (**28, 48**), or otherwise (**15**). Certain of the UV lines (0.365, 0.335, 0.313, 0.303, 0.254, etc.) may be more or less isolated by Cl (**36**), Cl-Br, Ag, G_{N_1}, and G_{N_2}. In the IR, the group between 1.0 and 1.8μ (strongest at 1.014 and 1.129μ) may be isolated from the other lines and in part from one another (*see* 4, *supra*). There is radiation at 300μ also.

(*b*) *Hydrogen Tube.*—For isolation of visible lines, *see* (**22**).

(*c*) *Helium Tube.*—For isolation of some of visible lines, *see* (**22**). In IR there is an intense line at 1.084μ and a weak one at 2.026μ. The yellow line is absorbed by X.

(*d*) *Bunsen Flame.*—Most of the energy is concentrated at 4.4μ and may be isolated by a gelatin filter of type D_3 (**12**).

(*e*) *Flame Spectra.*—Sodium D-lines absorbed by X (**16**).

(*f*) *Copper Arcs.*—Blinding yellow glare absorbed by X (**22**).

Classified References.—Commercial filters, *see* (**15, 16, 41, 44**); discussion of special filters (**6, 9, 10, 13, 14, 17, 19, 21, 22, 25, 28, 32, 34, 36, 37, 40, 47, 48, 49**); germicidal action of UV (**13**); absorption data of special value in construction of filters, quantitative (**1–6, 8, 9, 12–14, 17–24, 26, 27, 29, 30, 37–39, 42**); qualitative (**31, 33, 45**).

TABLE 1.—FILTERS AND THEIR SYMBOLS

τ = thickness of absorber, unit = 1 mm. IR-limit [UV-limit] = wave-length bounding the transmission band on its

IR [UV] edge: All filters except Cl and S are represented in Fig. 6.

Symbol	Filter	Lit.	Fig.
Ag	Ag chemically deposited on SiO_2; τ of Ag = 7.9×10^{-5}; no IR is transmitted	(23); *cf.* (38)	3
C	Aqueous (H_2O) solution: 57.0 g $CuSO_4.5H_2O$ per l of solution; τ = 10.00; transmits UV to about λ = 0.3μ; for IR-limit, *see* (6)	(17)	1
C-K	Two aqueous (H_2O) solutions in different glass cells; 57.0 g $CuSO_4.5H_2O$ per l, and 72.0 g $K_2Cr_2O_7$ per l: τ = 10.0 for each; transmits practically no IR, but *cf.* (6)	(17)	3
Ca	Calcite ($CaCO_3$): transmission $\perp$ axis; τ = 6.1; for IR-limit, *see* (35)	(39)	1
Cl	Cl-gas in quartz (SiO_2) cell	(37)	3
Cl-Br	Cl-gas and Br-vapor in quartz (SiO_2) cells: combined transmission	(37)	3
D_1, D_2, D_3	Dyed gelatin films: no data beyond 0.7μ; (most of curves G_4 to G_{14} can be approximately duplicated by such films)	(15); *cf.* (12)	1
EA	Ethyl alcohol (C_2H_5OH), chemically pure: τ = 10; IR-limit approximately that of H_2O (W, Fig. 2)	(39)	1
F	Fluorite (CaF_2), colorless: τ = 10; for UV-limit, *see* F_1 and F_2, Fig. 1	(42)	2
F_1	Fluorite (CaF_2), best quality, colorless: thin plates, value of τ is not stated; for IR-limit, *see* F, Fig. 2	(31)	1
F_2	Fluorite (CaF_2): transmission by prism and lenses; value of τ is not stated; data from Schumann's map; for IR-limit, *see* F, Fig. 2.	(31)	1
G'*	Cover-glass, special crown for UV transmission; τ is very small	(31)	1
G''*	Glass, special crown for UV transmission; τ = 1	(31, 44)	1
G'''*	Glass, special for UV transmission: τ = 0.39.	(22)	1
G_1*	Glass, common cover-glass; τ is very small	(31)	1
G_1'	Glass: τ = 11.9; for UV-limit, *see* (22)	(9)	2
G_2*	Glass, crown: τ = 1.68	(20, 22)	1
G_2'	Glass, crown: τ = 2.18; for UV-limit, *see* G_2 Fig. 1	(7, 11)	2
G_3*	Glass: τ = 8.30	(22)	1
G_4*	Glass: τ = 2.05	(20)	1
G_5* to G_{14}*	Glass, yellow, orange, or red: principal coloring agent is CdS or Se; τ = 0.88 to 4.23	(18, 20, 22)	1
GC_4	Glass; Co:† τ = 4.62	(16, 22)	3
GC_4'	Glass; Co:† τ = 3.13	(12)	5
GC_5	Glass; Co† + Cu:† τ = 2.59	(16, 22)	3
GC_5'	Glass; Co† + Cu:† τ = 2.40	(12)	5
GC_6	Glass; Co† + Cu:† τ = 2.99; IR transmission is somewhat similar to that of GC_5'	(22)	3
GC_7	Glass; Cu:† τ = 5.55	(16, 22)	3
GC_7'	Glass; Cu:† τ = 4.93	(12)	5
GC_8	Glass; Cr† + Cu:† τ = 2.99; IR transmission is somewhat similar to that of GC_7' and GC_9'	(16, 22)	3
GC_9	Glass; Mn† + Cr:† τ = 2.46; should be tested for possible violet transmission	(12, 16, 20)	3
GC_9'	Glass; Mn† + Cr:† τ = 2.46; should be tested for possible violet transmission	(12)	5
GN_1	Glass; Ni:† τ = 4.37; no IR transmission	(16, 22)	3
GN_2	Glass; Ni:† τ = 2.68; no IR transmission (12)	(16, 22)	3
GN_3	Glass; Ni:† τ = 3.20	(16, 22)	3
GN_3'	Glass; Ni:† τ = 2.85	(12)	5
G 980 A‡	Glass for UV transmission: τ = 5.0; practically no absorption if 0.3μ < λ < 0.8μ	(19)	4
G 984 B‡	Glass for UV transmission: τ = 5.3; middle of the transmission band at 0.5μ to 0.6μ has greater λ than that of GC_8	(19)	4
G 985 B‡	Glass for UV transmission: τ = 5.0	(19)	4
G 986 A‡	Glass for UV transmission: τ = 5.0	(19)	4
Gl	Glycerol, chemically pure: τ = 10; IR-limit approximately that of W, *see* (8, 38)	(39)	1
M	Mica: τ = 0.01; for IR-limit, *see* (3)	(13)	1
Q_1	Quartz (SiO_2), crystalline: τ = 0.2; for IR-limit *see* Q_2, Fig. 2	(31)	1
Q_2	Quartz (SiO_2), crystalline: τ = 2.0; no great difference between dextro, levo, transmission $\perp$, or $\parallel$ to axis; for IR-limit, *see* Q_2, Fig. 2	(31)	1
Q_3	Quartz (SiO_2), crystalline: τ = 4.77; for UV-limit *see* Q_1 and Q_2, Fig. 1	(9)	2
RS	Rock salt (NaCl): value of τ is not stated; for IR-limit, *see* RS_1, Fig. 2	(31)	1
RS_1	Rock salt (NaCl): τ = 10; for UV-limit, *see* RS, Fig. 1	(42)	2
S	Sylvite (KCl): τ = 10; strong, narrow absorption bands at λ = 3.18μ and λ = 7.08μ; free transmission through visible and into UV	(5, 42)	2
W	Water (H_2O) in cell with thin quartz (SiO_2) windows: τ = 10; for UV-limit, *see* W_1, Fig. 1.	(9)	2
W_1	Water (H_2O), distilled, in cell with fluorite (CaF_2) windows: long exposure; τ = 0.5; for IR-limit, *see* W, Fig. 2	(31)	1
W_2	Water (H_2O), pure, in cell with quartz (SiO_2) windows; τ = 20(?); for IR-limit, *see* W, Fig. 2	(29, 31)	1
X	Glass (22, 38) or solution (45) containing "didymium" (mixture of Nd and Pr)		6

* So far as known, all white, yellow, orange, and red glasses have IR transmissions similar to those of G_1' and G_2' (Fig. 2), *cf.* Fig. 6. Those containing Fe-impurities have a broad, weak absorption band at λ = 1.1μ, *cf.* (11, 12).

† Principal coloring material.

‡ Trade designation; made by Corning Glass Works, Corning, N. Y., U. S. A.

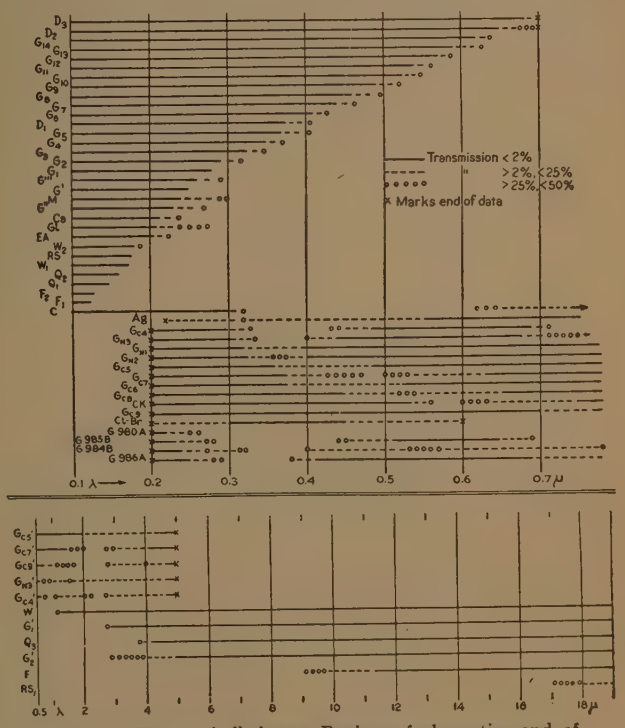


FIG. 6.—Filters of all classes: Regions of absorption and of transmission.

For more exact data, *see* Figs. 1 to 5; filters described in Table 1.

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(For a key to the periodicals see end of volume)

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(10) Coblentz, *48*, **7**: 439; 23. (11) Coblentz and Emerson, *32*, No. **93**; 19. (12) Coblentz, Emerson and Long, *31A*, **14**; 653; 19. (13) Coblentz and Fulton, *31A*, **19**: 641; 24. (14) Coblentz and Kahler, *31A*, **15**: 121; 20. (15) Eastman Kodak Co., *Wratten Light Filters*. 8th ed. 1927. Rochester, N. Y. (16) Gage, *Trans. Soc. Motion Picture Eng.*, **1924**: 37. (17) Gibson, *48*, **9**: 113; 24. (18) Gibson, *48*, **10**: 169; 25. (19) Gibson, *48*, **13**: 267; 26.

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SPECTROSCOPY

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SPECTROSCOPIC STANDARDS OF WAVE-LENGTH

Ch. Fabry

All wave-lengths (λ) given below are expressed in international ångstroms and are the wave-lengths in dry atmospheric air at 15°C and a pressure of one normal atmosphere. Some of them differ slightly from the corresponding values internationally accepted for use as secondary or tertiary standards. These differences are made necessary by the high precision of modern measurements and the very recent elimination of irregularities produced by the pole-effect (*see* p. 432). All arc lines refer to arcs in air at atmospheric pressure (not to arcs in a vacuum); those produced by arcs which are not satisfactorily defined are marked (*).

PRIMARY STANDARD

It is internationally agreed that in dry atmospheric air at 15°C and a pressure of one normal atmosphere the red line of cadmium, produced under the conditions described by Michelson (1, 9) and specified below, has the wave-length (3)

$$\lambda_{Cd} = 6438.4696\ \text{Å} \doteq 0.64384696\mu$$

This defines the length of the international ångstrom and of the micron (μ) as used in the measurement of wave-lengths. As so defined, 1 Å = 10^{-10} m and 1μ = 0.001 mm within the limits of experimental error.

The primary (cadmium) standard of wave-length shall be produced by high-voltage electric current in a vacuum-tube having internal electrodes and the form described by Michelson (11). The tube shall be maintained at a temperature not higher than 320°C, and shall have a volume not less than 25 cm³. The effective value of the exciting current shall not exceed 0.05 ampere. At room temperature the tube shall be non-luminous when connected to the usual high-voltage circuit.

Table 1.—Secondary Standards (2, 4, 5, 6, 7, 8, 10)

In arriving at the values here given, the papers mentioned have been critically compared. The table is divided into 3 sections: Fe-lines, Cu-, Ni-, and Si-lines that fill gaps occurring in the Fe-spectrum, and Ne-lines. Unit of λ = 1 Int. Å = $10^{-4}\mu$ = 10^{-8} cm.

Fe-Lines

As far as possible the values here tabulated refer to the Pfund arc (11) in air at atmospheric pressure. That arc satisfies the following conditions:

Anode is below and consists of a bead of iron oxide supported on a massive rod of iron or other good conductor of heat; cathode is above and consists of a rod of iron 6 or 7 mm in diameter, having close to its lower end a massive cooling cylinder of copper or brass. Current not over 5 amperes, 110 to 250 volts, arc 12 to 15 mm long; zone used is midway between the electrodes and not over 1.5 mm wide.

These values are the most accurate and are unmarked. Others, obtained with the arc between two rods of iron 6 to 7 mm in diameter, current about 6 amperes and no statement of either length of arc or of portion used, are marked (*).

λ_{Fe}	λ_{Fe}	λ_{Fe}	λ_{Fe}
*2373.737	3977.744	4966.097	6393.606
*2413.310	4021.870	4994.132	6430.852
*2562.541	4074.789	5001.872	6494.985
*2588.016	4076.638	5012.072	6546.245
*2628.296	4095.973	5041.759	6592.920
*2679.065	4107.492	5049.825	6677.994
*2714.419	4118.549	5083.343	6703.573
*2739.550	4134.680	5110.414	6733.164
*2778.225	4147.673	5123.723	6750.157
*2813.290	4156.803	5150.843	6752.724
*2851.800	4175.639	5167.491	6806.851
*2874.176	4184.894	5192.353	6828.612
*2912.157	4191.436	5202.339	6841.355
*2941.347	4203.987	5216.277	6843.676
*2987.293	4219.364	5232.948	6855.179
*3030.152	4233.609	5250.650	6885.772
*3075.725	4245.260	5266.564	6916.709
*3125.661	4282.406	5270.361	6933.628
*3175.447	4315.087	5302.309	6945.211
*3225.790	4352.738	5324.187	6951.271
*3271.003	4375.933	5328.534	6978.857
*3323.739	4427.313	5341.026	6988.531
*3370.789	4466.556	5371.493	6999.912
*3399.337	4494.568	5405.779	7022.976
3445.153	4531.152	5434.527	7038.255
3485.343	4547.851	5455.613	7068.418
3513.821	4592.655	5497.520	7090.410
3556.882	4602.945	5506.783	7107.464
3558.518	4647.437	5569.626	7112.178
3606.682	4691.414	5586.763	7130.946
3640.392	4707.282	5615.652	7132.996
3676.314	4710.287	5658.825	7164.472
3677.630	4733.596	*5763.013	7181.222
3724.381	4736.782	6024.065	7187.341
3753.615	4741.533	6027.058	7207.422
3805.346	4772.818	6065.489	7219.690
3843.261	4789.654	6136.620	7223.670
3850.820	4859.749	6137.697	7239.896
3865.527	4878.219	6191.563	7284.843
3906.482	4903.318	6230.729	7288.764
3907.937	4919.001	6265.141	7293.073
3935.816	4924.776	6318.023	7307.938
3940.882	4939.691	6335.338	7311.103

Fe-Lines.—(*Continued*)

λ_{Fe}	λ_{Fe}	λ_{Fe}	λ_{Fe}
7320.694	7511.047	7710.397	8198.960
7386.394	7531.178	7748.282	8220.413
7389.423	7546.177	7780.594	8327.069
7401.691	7568.931	7832.233	8331.956
7411.184	7583.801	7937.172	8387.787
7418.676	7586.050	7945.882	8468.422
7443.031	7620.538	7998.980	8514.088
7445.778	7653.783	8028.356	8661.915
7491.678	7661.230	8046.084	8688.641
7495.092	7664.306	8085.207	8824.238
7507.300			

Cu-, Ni- and Si-Lines

(*a*) Copper: Arc between rods of Cu 4 mm in diameter, current = 4 to 5 amperes. (*b*) Silicon: Arc between ordinary rods of carbon; light from electrodes is eliminated. (*c*) Nickel: Arc between rods of Ni 5 mm in diameter, current = 6 amperes.

λ_{Cu}	λ_{Cu}	λ_{Cu}	λ_{Si}
*2112.105	*2242.622	*2369.891	*2528.516
*2126.047	*2276.261	λ_{Si}	λ_{Ni}
*2189.631	*2303.134	*2435.159	*5857.759
*2218.107	*2334.816†	*2506.904	*5892.882

* No statement of length of arc or of portion used. † A Sn-line.

Ne-Lines

The lines are emitted by a tube containing Ne at a pressure of a few mm of mercury.

λ_{Ne}	λ_{Ne}	λ_{Ne}	λ_{Ne}
5400.562	6096.163	6334.428	6717.043
5852.488	6143.062	6382.991	6929.466
5881.895	6163.594	6506.528	7032.412
5944.834	6217.280	6532.883	7173.938
5975.534	6266.495	6598.953	7245.165
6029.997	6304.789	6678.276	7535.785
6074.338			

Table 2.—Tertiary Standards (11)

All the following tertiary standards are Fe-lines emitted by a Pfund arc under the conditions stated in Table 1. Their wave-lengths have been determined by interpolation from those of the secondary standards, and the published values have been corrected so as to make them accord with the values adopted for the secondary standards. Unit of λ = 1 Int. Å = $10^{-4}\mu$ = 10^{-8} cm.

λ_{Fe}	λ_{Fe}	λ_{Fe}	λ_{Fe}
3370.786	3485.343	3586.116	3659.521
3379.023	3489.674	3589.109	3669.524
3380.115	3495.290	3594.635	3676.314
3392.657	3497.111	3603.207	3677.630
3396.982	3497.844	3606.683	3679.917
3399.337	3506.501	3608.863	3684.113
3401.523	3513.821	3617.792	3687.460
3402.261	3521.265	3618.771	3690.732
3407.465	3529.820	3621.465	3695.055
3413.136	3541.087	3623.189	3702.035
3417.845	3542.080	3625.149	3704.464
3418.511	3545.642	3630.353	3705.569
3424.288	3556.882	3631.467	3707.051
3427.124	3558.518	3632.043	3711.227
3445.153	3565.382	3638.301	3715.916
3447.282	3576.761	3640.393	3719.936
3450.334	3581.196	3645.826	3722.566
3458.307	3582.202	3647.845	3724.381
3465.864	3584.664	3649.510	3727.623
3476.706	3585.322	3651.472	3732.400

Table 2.—(*Continued*)

λ_{Fe}	λ_{Fe}	λ_{Fe}	λ_{Fe}
3733.320	3841.052	3966.066	4154.501
3734.869	3843.261	3967.423	4156.803
3737.135	3846.805	3969.260	4170.904
3738.310	3849.971	3971.325	4175.639
3742.624	3850.821	3977.744	4177.596
3745.564	3852.577	3981.774	4181.758
3745.904	3856.373	3983.960	4184.894
3748.265	3859.914	3986.176	4191.436
3749.489	3865.527	3990.378	4202.030
3753.615	3867.220	3997.395	4203.987
3756.943	3871.752	4005.246	4213.649
3758.237	3872.505	4009.716	4216.185
3760.054	3873.764	4014.534	4219.364
3763.792	3878.022	4021.870	4226.423
3765.544	3878.575	4031.964	4233.609
3767.196	3883.286	4044.614	4245.260
3774.827	3884.362	4045.816	4250.789
3776.459	3886.286	4062.486	4266.968
3781.191	3887.051	4066.979	4267.830
3785.951	3888.518	4067.275	4271.764
3786.681	3895.658	4067.983	4282.406
3787.883	3899.709	4074.789	4285.447
3790.096	3902.950	4076.638	4294.128
3794.342	3903.902	4085.008	4298.041
3795.005	3906.483	4095.973	4305.455
3797.518	3907.937	4098.183	4307.907
3798.514	3910.847	4100.740	4315.087
3799.550	3917.185	4107.492	4325.764
3805.346	3920.260	4109.806	4327.099
3806.702	3922.914	4114.449	4337.050
3807.540	3925.945	4118.549	4346.559
3808.732	3927.921	4120.210	4351.550
3814.527	3930.299	4121.805	4352.738
3815.843	3932.631	4122.519	4358.505
3821.161	3935.816	4127.611	4367.583
3824.445	3937.331	4132.060	4369.776
3825.885	3940.883	4132.902	4375.933
3827.826	3942.443	4134.680	4383.549
3833.313	3948.778	4137.000	4387.898
3834.225	3952.605	4143.418	4390.955
3839.260	3956.459	4143.870	4404.753
3840.440	3956.680	4147.673	4407.715

Table 2.—(*Continued*)

λ_{Fe}	λ_{Fe}	λ_{Fe}	λ_{Fe}
4408.419	4678.453	5166.286	6127.913
4415.126	4691.414	5167.491	6136.622
4422.572	4707.282	5168.901	6137.697
4427.313	4710.287	5171.599	6157.730
4430.620	4733.596	5192.353	6165.364
4435.153	4736.782	5198.712	6173.340
4442.345	4741.533	5202.339	6191.564
4443.197	4745.805	5216.277	6200.319
4447.723	4772.818	5227.189	6219.287
4454.384	4786.809	5232.948	6230.730
4459.122	4788.759	5242.492	6252.563
4461.655	4789.655	5250.650	6254.263
4466.556	4802.881	5266.564	6265.141
4476.022	4859.749	5269.537	6297.799
4489.742	4878.220	5270.361	6318.024
4490.085	4903.318	5302.309	6322.692
4494.568	4919.002	5307.361	6335.338
4514.190	4924.776	5324.187	6344.157
4517.528	4939.691	5328.534	6380.749
4528.619	4966.099	5332.901	6393.607
4531.152	4994.132	5341.026	6421.357
4547.851	5001.872	5371.493	6430.853
4587.134	5012.072	5397.132	6462.733
4592.655	5041.074	5405.779	6475.633
4602.006	5041.759	5429.700	6494.987
4602.945	5049.825	5434.527	6518.376
4619.296	5051.637	5446.920	6546.247
4630.126	5083.343	5455.613	6575.023
4632.915	5098.704	5497.520	6592.920
4638.017	5110.414	5501.469	6609.118
4647.437	5123.723	5506.783	6663.447
4654.502	5127.364	6027.058	6677.994
4667.458	5150.843	6065.489	6750.160
4673.168	5151.914		

LITERATURE

(For a key to the periodicals see end of volume)

(1) Babcock, *538*, **2**: 40; 25. (2) Babcock, *21*, **66**: 256; 27. (3) Benoit, Fabry and Perot, *238*, **15**: 1913. (4) Buisson and Fabry, *51*, **7**: 169; 08. (5) Burns, *48*, **11**: 301; 25. (6) Kayser, *Trans. International Union for Cooperation in Solar Research*, **3**: 30, 139; 11. (7) Meggers and Kiess, *31A*, **19**: 273; 24. (8) Meggers, Kiess and Burns, *31A*, **19**: 263; 24. (9) Michelson, *238*, **11**: 1895.
(10) Mitra, *16*, **19**: 315; 23. (11) St. John, *538*, **1**: 35; 22.

EMISSION SPECTRA OF ELEMENTARY SUBSTANCES

H. KAYSER

In the following table are given the wave-lengths (λ) of selected lines from the spectra of air, of all known elements except Ac, Ma, Pa, Po, Re, UX_2, and certain doubtful, or unidentified elements. The number of lines given in each case is determined by the spectroscopic importance of the element and by the number of lines which its spectrum contains; the strongest and the most easily reversed lines throughout the spectrum have been given, and the distribution of the lines has been chosen so that the list will satisfy the practical requirements of such a table and will exhibit all the characteristics of the spectrum. In the spark-spectrum of air all the observed lines are given, although many of them are false, being metallic lines. For each element, are given the more important literature references from which the data were taken; for a more complete list of references, *see* Kayser, *Handbuch der Spektroscopie*, Vols. 5 to 7, or Watts, *Index of Spectra*. It is assumed that the wave-length of a line is the same in the arc as in the spark, that changes in λ arise only from pressure, magnetic and electric fields, pole-effect, and apparent shifts from unsymmetrical broadening. The data given refer to atmospheric pressure, except in those cases in which the observation must be made under reduced pressure. The precision of measurements in the infra-red is so low that the correction from the Rowland to the international scale is unimportant; in all other cases λ is expressed in international ångstroms.

The values given for λ are weighted means of the best determinations available, and consequently are to some extent arbitrary. The relative intensities of the lines depend upon so many conditions, frequently undefined or even undefinable, that an average is meaningless. But the intensity of a line is an important characteristic of it, and in very many cases the relative intensities vary from one type of spectrum—arc, spark, Geissler tube—to another much more than they vary with the conditions in any one

type; for this reason a kind of average, or typical value of the relative intensity is given.

Spectra obtained by means of the arc, spark, or Geissler tube are generally mixtures of different spectra. Some of the lines belong to the neutral atom (denoted by A or AI), some to the simply ionized atom (A^+ or AII), some to the doubly ionized atom—the atom which has lost two electrons—(A^{++} or AIII), etc. It is now possible to determine in many cases the particular type of atom to which a given line belongs. In such cases, the type is indicated in the following table by placing before the wave-length the proper symbol (I, II, III . . .).

WAVE-LENGTHS (λ) OF SELECTED LINES IN EMISSION SPECTRA OF AIR AND OF ELEMENTARY SUBSTANCES

There are no data for Ac, Ma, Pa, Po, Re, and UX_2. For basis of selection of lines given, etc., *see* preceding text. Uncertainty in λ is not over 3 units in the last figure. Numbers in the columns A, S, and G indicate the relative intensities of the lines in the arc, spark and Geissler-tube spectrum, respectively; in each case 1 generally denotes the weakest and 10 the strongest line, but very weak lines may be marked 0, and very strong ones 15, 20, 25, or 30. I, II, III . . . indicate that the line is emitted by the neutral, the simply ionized, the doubly ionized . . . atom; R = easily reversed, u = unsharp, broad; U = very unsharp, very broad; r [v] = unsymmetrically broadened, the excess broadening is on the red [violet] side, *i.e.*, towards the longer [shorter] wave-lengths; the number of components of an unresolved multiple line is indicated by the letters d, tr, qr, qn, s; where d = 2, tr = 3, qr = 4, qn = 5, s = 6.

Unit of λ = 1 Å = 0.1 $m\mu = 10^{-4}\mu = 10^{-8}$ cm.

Air (3, 74, 75, 91, 101, 102, 128, 186, 198, 199, 255, 259, 274)			Air.—(*Continued*)			Air.—(*Continued*)			Air.—(*Continued*)		
λ	S	E*	λ	S	E*	λ	S	E*	λ	S	E*
8 719.2	0	N	7 442.7	10	N	5 747.5	1	N	4 942.5	1	N
12.0	0	N	32.9	0		30.6	2	N	41.0	1	N
03.8	0	N	24.0	8	N	10.7	2	N	34.8	1	N
8 692	0		7 384.5	1	A	5 686.2	3	N	24.6	2	O
86.4	0	N	7 157.4	9	O(?)	79.5	10	N	06.8	1	O
83.7	1	N	7 067.6	0	A	75.9	3	N	4 895.3	1	N
80.6	2	N	6 965.9	1	A	66.6	5	N	90.9	0	O
30.0	0		50	0U		45.6	1	N	79.7	1	N
8 594	0		6 887.6	1		5 592.3	0	O	71.6	0	O
8 446.8	5	O	64	0		66	0	N	60.3	1	N
8 242.8	4	N	11.9	0		52.0	2	N	56.8	1	O
30.2	0	O	6 721.3	1		43.4	3	N	47.7	1	N(?)
23.5	4	N	6 654.8	2		35.2	5	N	10.3	2	N
16.7	7	N	40.7	0		30.2	3	N	05.9	1	N
11.1	2	N	10.4	6	N	26.2	2	N	03.3	5	N
00.7	1	N	6 563.2	3	H	5 495.7	2	N	4 793.7	2	N
8 188.4	4	N	6 482.0	5	N	80.1	1	N	88.2	4	N
85.3	4	N	56	0	O	78.1	0	N	81.2	0	N(?)
7 952.3	2	O	6 379.3	2	N	62.8	1	N	79.8	2	N
51.1	3	O	70.7	0		54.1	1	N	74.2	1	N
47.8	4	O	58.1	0	N	52.1	1	N	64.6	1	N
7 775.6	6	O	41.5	0	N	32.1	0	N(?)	51.2	1	O
74.3	7	O	6 284.3	1	N	11.5	1	N	35.7	1	N
72.1	10	O	6 171.0	2	O	5 356.4	0	N	18.4	2	N
7 635.7	1	A	58.1	0	O	51.2	0	N	09.9	2	O
7 515.2	0	A	5 952.4	4	N	41.2	1	N	05.4	3	O
05.8	0	A	41.6	10	N	38.7	1	N	05.1	1	N
7 479	0	O	40.5	1	N	28.6	0	N	03.1	0	O
68.7	10	N	31.8	7	N	25.1	0	O	4 699.2	3	O
58.7	0		27.8	4	N	20.5	1	N	97.6	0	N(?)
			5 767.4	2	N	5 281.7	0	N	76.2	3	O
						63	0		74.9	1	N
						50.6	1	N(?)	61.6	5	O
						06.5	1	O	54.5	1	N
						5 190.6	1	N	50.8	2	O
						85.1	0	N	49.1	4	O
						83.2	0	O	43.1	4	N
						79.4	1	N	41.8	3	O
						75.9	2	N	40.5	1	N
						73.4	1	N	38.8	2	O
						72	1	N	34.0	1	N
						60.1	0	O	30.53	10	N
						50	0		21.39	4	N
						43.6	0	O	13.84	3	N
						36	0		09.4	1	N
						5 073.5	0	N	07.14	4	N
						61.8	0	N	01.48	4	N
						45.1	2	N	4 596.12	3	O
						32	0		90.93	3	O
						25.7	2	N	52.5	2	N
						22.9	1	N	44.8	1	N
						16.4	2	N	29.9	2	N
						13.9	0		14.8	2	N
						10.6	2	N	07.62	2	N
						07.4	3	N	4 477.7	1	N
						05.2	6	N	69.4	1	O
						01.4	6	N	67.8	2	O
						4 994.4	3	N	65.4	2	O
						91.3	1	N	60.1	1	N
						87.4	1	N	52.4	2	O
						64.7	0	N	47.04	6	N
						55	1	O	43.3	1	O
						43.0	1	O	34.0	0	N

* Symbol of elementary substance to which the line is due.

Air.—(*Continued*)

λ	S	E*
4 432.4	2	N
30.1	1	N
25.9	1	N
17.0	5	O
14.9	6	O
01.2	1	N
4 396.0	1	O
92.4	0	N(?)
79.6	1	N
71.4	1	N
69.2	1	O
66.87	3	O
61.6	0	N
51.3	2	O
49.40	4	O
48.0	2	N
47.44	2	O
45.54	3	O
36.8	2	O
31.9	1	O
31.04	1	N
28.5	1	O
27.5	1	O
25.7	1	O
19.62	3	O
17.11	3	O
03.7	1	O
4 275.9	1	N
66.4	2	N
53.7	2	O
41.75	2	N
36.8	3	N
28	2	N
23.3	1	N
11.1	1	N
06.7	2	N
4 199.3	0	N
89.8	6	O
85.5	4	O
76.2	2	N
69.36	1	O
53.5	3	O
45.90	3	N
43.7	1	O
42.2	1	O
33.70	2	N
32.88	2	O
29.5	1	O
24.1	2	O
21.5	2	O
20.5	2	O
19.3	4	O
14.0	0	O
12.09	1	O
10.84	2	O
05.00	3	O
03.3	2	N
4 097.2	3	N
93.00	2	O
89.1	1	O
85.20	2	O
78.9	2	O
75.93	8	O
72.25	8	O

Air.—(*Continued*)

λ	S	E*
4 069.90	8	O
63.2	1	N
57.8	1	N
41.3	3	N
34.9	2	N
25.7	1	N
14.0	1	O
3 995.1	10	N
82.76	2	O
73.30	4	O
68.4	1	A(?)
55.9	4	N
54.4	1	O
47.45	1	O
45.1	1	O
40.2	1	N
33.6	0	?
19.10	6	N
12.1	3	O
09.1	1	N
07.6	1	O
3 893.3	1	N
82.3	2	O
64.6	1	O
56.7	1	N
51.2	1	O
50.6	1	N
48.04	1	O
45.1	0	N
42.8	1	N
39.1	2	N
30.7	1	N
04.0	1	O
3 770.9	1	N
59.8	1	O
54.5	1	O
49.51	5	O
29.3	1	N
27.34	4	O
12.7	2	O
09.2	1	O
07.3	1	O
02.9	1	
3 639.6	3	
09.8	1	
3 594.6	1	
89.0	1	
77.2	1	
70.3	1	
60.6	1	
14.8	1	
3 491.9	2	
71.2	2	
50.9	1	
37.32	3	N
08.3	2	O
3 390.3	2	O
77.2	2	O
74.0	2	N
70.9	1	N
67.3	1	N
65.8	1	N
54.08	1	O
44.8	1	

Air.—(*Continued*)

λ	S	E*
3 331.8	2	N
29.5	2	N
25	1	O
20.7	2	O
18.8	1	
12.5	1	O
01.9	1	
3 288.9	1	
65.2	1	O
3 158.7	1	
39.3	2	O
35.3	1	O
30.1	1	
3 059.15	2	
47.0	1	
07	1	O
2 927.5	1	
2 858.3	1	
2 795.5	1	
55.9	2	
49	1	
46.7	1	
39.8	1	
2 599.5	2	
14.5	1	
07.2	2	
2 445.5	1	O
33.6	1	O
06.9	1	
04.9	2	
2 399.4	1	
95.62	1	
82.1	2	
18.5	1	O
2 287.9	1	N

A (83, 129, 162, 175, 181, 184, 202, 237)

	λ	Rd†	Bl†
	13 719	4	
	13 505	4	
	12 500	30	
I	11 590	8	
I	10 640	12	
I	9 658.9	7	
I	9 225.9	5	
I	9 123.7	10	
I	8 521.442	5	
I	8 424.648	10	
I	08.213	6	
	05	6	
I	8 264.523	5	
I	8 115.308	10	
I	03.692	3	
I	8 014.785	3	
I	06.157	8	
I	7 948.176	5	
I	7 724.210		
I	23.759	5	
I	7 635.106	6	
I	7 514.650	4	

A.—(*Continued*)

	λ	Rd†	Bl†
I	7 503.868	4	
	7 435.5	1	
I	7 383.979	5	
	72.119	1	
	53.316	1	
	15.9	1	
	11.6	1	
I	7 272.935	3	
	06.986	1	
I	7 147.042	1	
I	7 067.217	5	
	30.250	2	
I	6 965.430	6	
	37.666	2	
	6 888.8	1	
	71.290	4	
	6 786.3	1	
	56.4	1	
	52.831	5	
	19.2	2	
	6 698.9	3	
	84.4	1	
I	77.282	5	
	64.1	3	
	60.7	3	
	40.2		0
	04.9	3	
	6 513.7	1	
	6 493.9	2	
	81.0	2	
	66.5	3	
	31.6	3	
	16.307	6	
	6 384.5	4	
	69.6	3	
	64.8	3	
	07.6	3	
	6 296.8	3	
	78.6	2	
	48.5	3	
	43.4		2
	15.9	4	
	12.4	4	
	6 172.9	4	
	72.2		4
	70.1	3	
	65.1	3	
	55.1	3	
	45.4	4	
	27.4	3	
	21.7	2	
	19.5	2	
	14.8		3
	13.4	2	
	05.8	4	
	04.5	2	
	01.1	2	
	6 098.7	4	
	90.8	3	
	67.7	1	
	64.7	3	
	59.4	5	

† Rd [Bl] = intensity of the line in the red [blue] spectrum.

A.—(*Continued*)

λ	Rd†	Bl†
6 052.6	4	
43.2	6	
32.127	6	
25.4	3	
13.6	3	
05.8	2	
5 999.2	2	
87.3	3	
71.7	3	
68.4	2	
64.5	2	
49.3	3	
43.0	3	
40.9	2	
28.5	4	
27.1	2	
16.6	2	
12.1	5	
00.5	1	
5 888.7	4	
82.7	3	
60.4	3	
32.1	1	
02.2	1	
5 772.3	2	
39.7	3	
5 691.7	1	
82.4	2	
59.2	3	
50.8	5	
48.8	2	
18.1	2	
07.0	6	
5 597.7	2	
81.6	2	
72.6	4	
59.7	2	
58.8	5	
25.1	2	
06.4	2	
5 495.9	6	
73.6	2	
67.2	2	
57.8	2	
51.7	5	
43.3	2	
42.1	1	
40.1	2	
21.6	4	
10.6	2	
5 373.6	2	
05.8		6
5 287.0		3
54.4	2	
52.9	3	
21.6	3	
17.0		2
5 188.3	3	
87.3	3	
77.6	1	
76.4		3
65.8		4
62.4	4	

A.—(*Continued*)

λ	Rd†	Bl†
5 152.5	3	
45.40		4
42.0		4
5 063.0	1	
62.1		6
60.2	3	
54.3	1	
49	2	
24.3		1
17.2		5
09.3		6
4 972.2		3
65.1		4
55.1		2
42.9		2
33.2		4
04.8		2
4 894.8	1	
88.7		2
88.1	1	
82.3		2
79.9		6
67.5		4
65.9		4
47.77		6
05.99		8
4 768.4	1	
64.85		4
35.87		5
26.83		4
02.317	4	
4 657.88		4
37.17		3
I 28.445	5	
09.56		6
4 596.096	5	
89.89		6
79.35		6
47.7		2
45.06		6
I 22.325	4	
I 10.733	8	
02.95		3
01.5	1	
4 498.5		2
91.0		2
88.2		2
81.83		5
33.90		2
31.00		4
30.18		4
25.99		8
01.00		5
00.09		4
4 379.64		6
71.31		5
70.75		5
I 63.78	3	
62.04		3
52.21		4
48.0		10
I 45.168	7	
I 35.29	6	

A.—(*Continued*)

λ	Rd†	Bl†
I 4 333.561	7	
32.04		3
31.17		7
09.15		2
00.66		2
I 00.101	8	
4 282.88		4
77.5		8
I 72.169	8	
66.4		6
66.286	8	6
59.362	9	
I 51.184	5	
37.21		4
28.2		7
26.98		3
22.64		4
18.66		3
03.4		2
01.9	2	
I 00.678	9	
I 4 198.316	8	
I 91.027	8	
I 90.714	5	
I 81.884	7	
79.30		3
78.38		3
I 64.180	7	
I 58.591	9	
56.14		4
52.7	3	
31.78		6
28.6		3
12.82		3
03.95		9
4 099.45		2
82.41		4
80.61		2
79.61		4
77.03		2
76.70		6
72.43		4
72.02		7
I 54.50	3	
52.96		4
45.88	4	
I 44.419	8	
42.89		6
38.83		4
35.45		3
33.85		3
I 32.96	2	
13.84		7
3 992.03		4
79.40		5
74.52		4
68.37		4
60.45		3
58.40		3
I 48.980	7	
I 47.55	4	
46.10		4
44.30		5

A.—(*Continued*)

λ	Rd†	Bl†
3 932.56		5
31.20		3
28.61		8
25.76		4
14.78		5
11.56		3
07.70		3
I 3 899.90	2	
I 94.64	3	
91.99		6
91.39		4
80.29		3
75.25		5
72.14		4
68.55		7
I 66.14	1	
50.56		9
45.37		3
I 34.65	5	
30.43		3
26.80		4
09.46		4
08.58		2
03.23		3
3 799.47		3
95.38		5
86.42		4
I 81.33	3	
80.89		7
I 75.4	1	
70.61		3
70.4	3	
66.14		3
65.32		6
63.59		4
53.5		3
37.92		5
29.33		D
24.53		3
20.46		3
18.25		5
17.21		3
I 3 696.5	1	
I 90.9	1	
80.1	4	
78.31	5	
70.7	3	
60.52		3
59.5	2	
56.12		2
55.35		4
50.9		3
I 49.9	3	
I 43.1	2	
39.86		4
37.86		4
37.08		3
I 34.46	4	
I 32.65	4	
22.18		4
I 06.53	5	
I 3 599.3	1	
88.49		9

A.—(*Continued*)

	λ	Rd†	Bl†
	3 582.39		6
	81.66		5
	76.65		8
I	72.27	2	
I	67.68	4	
	65.06		3
I	64.41		2
I	64.3	2	
I	63.2	3	
	61.06		6
I	59.54		7
	56.0	2	
	55.31	2	
I	54.31	4	
	48.53		3
	45.86		7
	45.64		7
	35.37		5
	21.97		2
	21.29		3
	20.02		4
	14.40		6
	11.16		5
	09.80		4
	09.36		2
	03.59		2
	3 499.68		3
	91.57		8
	91.29		5
	80.51		5
	78.26		4
	76.79		7
	66.3		3
	64.20		4
I	61.06	3	
	54.15		3
	30.48		2
	29.69		2
	21.67		3
I	3 393.8	3	
	92.8	2	
	91.77		5
	88.54		5
	76.47		4
	73.5	2	
	70.93		2
	66.61		2
	58.51		4
	50.97		4
	44.73		4
	36.15		4
	25.49	2	
I	19.30	2	
	11.19		5
	07.23		4
	01.81		6
	3 295.3	2	
	93.65		4
	85.77		7
	81.71		5
	63.58		3
	49.83		3
	43.72		3
	12.62		2

A.—(*Continued*)

λ	Rd†	Bl†
3 204.35		3
3 181.09		4
69.71		5
61.44		5
39.06		5
3 093.40		6
34.6	3	
33.6		3
29.0		4
21.8	3	
2 979.1		6
68.3	2	
67.2	5	
55.4		5
43.0		7
31.5		2
24.7		3
2 896.8		2
91.7		4
84.1		4
78.8		3
73.4	3	
65.9		4
55.2		3
42.6		2
33.5	3	
06.2		6
02.1	3	
2 796.7		2
69.6		6
62.0		3
53.8		8
44.8		8
32.6		6
08.3		8
2 647.5		8
14.5	4	
2 562.2		6
44.7		6
16.7		8
16.2	4	
15.5		8
12.2		3
00.3		4
2 499.4		4
90.9		6
80.8		5
79.1		6
52.9		1
38.7		6
15.6		6
04.3		4
2 395.6		4
64.1		4
50.5		4
44.3		5
37.7		5
31.6		4
16.4		4
13.9		4
09.3		4
2 281.5		5
52.3		4
43.6		4

A.—(*Continued*)

λ	Rd†	I†B
2 234.6		4
19.8		4
2 050.4		1
1 886.1		7
79.7		8
77.7		8
73.2		10
68.7		8
65.9		8
55.7		9
43.1		9
36.3		9
31.4		9
30.6		10
20.0		7
1 788.1		5
1 675.6		7
73.5		7
69.7		7
00.7		5
1 589.5		4
1 460.1		5
1 335.8		7
34.5		7
33.7		5

Aldebaranium, *see* **Yb**

Ag (**24, 59, 75, 90, 91, 101, 111, 123, 128, 181, 205, 214, 223, 274, 276**)

	λ	A	S
	39 951	8	
	889	5	
I	18 382	1	
I	307	1	
I	17 415	1	
I	16 819	3	
I	12 551	1	
I	8 273.58	10	
I	7 687.85	10	
	6 037		2
	5 970		1
	5 666.4	4u	2u
	5 590		1u
	70		1U
	58		1U
	45.65	4r	
	29.9	2	
	23.7	3	
	5 494		1U
	89		3U
I	71.51	6	5
I	65.43	10	6
	03		1U
	01		1U
	5 333.3	2r	
	29.7	4r	
	5 276.4	1r	
I	09.04	10R	8
	4 888.3	2u	
	74.16	2r	1
	48.1	2U	

Ag.—(*Continued*)

	λ	A	S
	4 677.9	2u	1
I	68.54	8r	3
	15.9	3U	1
	4 556	3U	1
I	4 476.06	6	4
	47.0		1
	4 396	2u	1
	85		1
	79.24	2u	
	11.05	2r	2
I	4 212.01	8R	4R
	4 085.9		3
I	55.25	8R	3
	3 985		2
I	81.63	4r	1
	49.4	1	2
I	3 840.79	2	1
	10.7	2u	1
	3 710	1	
I	3 682.3	2u	1
	24.2	1u	
	16		1
	3 542.5	3	2
	20	1	
	07	1	
	05.1		1
	01.8	3	1
	3 475.8		2
	69.2	1	1
	56	1	
	13	1	
	09	1	
I	3 382.88	10R	9R
	64		1
	52		1
	49	1	
	31.8		2
	12.6		1
	05.7	2	
	01.5		2
	3 299.4		2
	89.2		2
	80.67	10R	9R
	67.33		1
	52.8		1
	49.8		1
	44.97		3
	41.3		1
	33	3u	1
	23		2
	16.7		1
	15.6	2	1
	07.3		1
	00.0		1
	3 191.8		1
	87.8		1
	85.1		1
	80.7		2
	73.6		1
	72.3		1
	70.6	2	1
	53.1		2
	30.0	3	1
	17.8		1

Ag.—(*Continued*)

	λ	A	S
	3 115		1
	3 099.11	2	1
	12.9		1
	2 983.52		1
	38.5	4	4
	34.2		6
	29.3		5
	20.0		3
I	02.08		4
	2 896.46		4
	73.59	2	4
	24.40	6	1
	15.6		4
	2 799.64		6
	86.5		3
	67.5		8
	56.4		6
	43.9		3
	21.79	3	2
	12.1		4
	2 688.4		3
	81.4		4
	60.4	3	5
	56.8		6
	28.6		2
	14.5		6
	06.14		6
	2 595.6		3
	80.7		6
	75.5	4U	1u
	67.15		2
	64.42		3
	53.41		2
	35.3		5
	06.65	2	5
	04.07		4
	2 486.7		2
	85.78		2
	80.42		4
	77.30		6
	73.88		7
	72.94		2
	62.27		4
	60.32		5
	53.37		6
	47.91	2	7
	44.20		4
	37.77	3	8
	29.65		7
	20.12		5
	13.22	4	8
	11.38		7
	02.57		3
	2 395.66		2
	92.97		2
	90.57		3
	86.8		2
	86.32		3
	83.20		2
	75.0	4U	3
	63.99		4
	62.19		3
	58.85		5

Ag.—(*Continued*)

λ	A	S
2 357.92		6
31.35	4	6
25.1		4
24.63	2	6
21.52		3
20.24	2	6
17.03	2	5
12.4	4U	2
09.54	6R	4
2 279.97	1	5
77.38		2
75.24		2
53.46		2
48.73	3	3
46.38	3	3
40.42		2
38.36		2
29.51	2	4
26.12		2
19.70		2
11.18		2
08.4	1	1
05.9	1	2
02.1	2	2
2 192	1	1
86.76	2	3
71.7		1
70.9		1
66.5	2	2
62.0		2
45.6	1	3
25.4		1
20.4	1	2
13.8	2	3
2 070.0		1
65.9		4
61		1
33.8		4
00.6		3
1 999.5		2
56.9		3
32.3		2
16.3		4
1 889		4
80		4
73		4
60		4
39		3
16		3
02		4
1 794		4
72		4
69		4
51		6
22		3
1 693		6
74		2
56.8		5
1 566		6
39		4
1 496		4
86		4
45		5

Al (13, 32, 34, 59, 60, 62, 74, 75, 78, 90, 91, 106, 111, 163, 205, 210, 276)

	λ	A	S
I	39 108		
I	21 166		
I	21 098		
I	16 752		
I	20		
I	13 151		
I	25		
I	11 255		
I	8 774.5	5r	
I	7 836.9	6r	
	7 466		
	7 362.5	2r	
I	6 698.73	3	
I	96.07	3	
II	6 243.347		10
II	31.759		7
	6 176	1u	
	51.7	1u	
II	5 861.53		7
III	5 722.65		6
III	5 696.45		5
II	5 593.23		10
I	57.95	2	
I	57.05	2	
III	5 163.90		7
III	50.86		5
I	05	d	
III	4 701.65		6
II	4 663.054		10
II	4 585.820		6
III	29.176		6
III	12.534		5u
III	4 479.968		5u
II	4 226.812		6
I	3 961.537	10R	8R
I	44.025	10R	8R
II	00.68		2
III	3 713.10		3u
III	02.09		2u
II	3 655.00		8d
III	12.35		7u
III	01.62		7u
II	3 587.06		10u tr
II	3 443.65		6
I	3 092.85	6R	4R
I	92.718	10R	8R
I	82.162	10R	8R
	66.16	4	2
	64.31	4	2
	59.93	2	1
II	57.15	4	10
	54.70	4	2
II	50.08	4	8
III	2 907.5		10
II	2 816.3		10u
III	2 762.81		9
II	2 669.17		10
I	60.394	10R	5R
I	52.484	10R	4R
II	31.73		7u
I	2 575.44	3R	2

Al.—(*Continued*)

	λ	A	S
I	2 575.112	10R	6R
II	67.996	10R	6R
II	45.60		6
I	2 378.43	3	1
I	73.36	2R	2R
I	73.13	8R	4R
I	72.06	3	3
II	69.30	1	4
I	67.06	8R	4R
II	21.56	2	6
I	12.4		1
I	2 269.21	2R	
I	69.09	4R	2R
I	63.73	2	
I	63.45	4R	2R
I	58.0	2	
I	10.05	2R	
I	04.63	2R	
I	2 199.57	1	
I	74.02	1R	1
I	68.00	1R	1
II	2 094.8		5
II	16.1		1
II	1 989.8		8
III	35.2		7
II	30.3		2
III	1 862.90		10
II	62.48		10
II	58.15		7
III	54.67		10
	18.3		2
	1 792		3
	77		4
II	67.6		9
II	65.7		7
II	63.9		10d
II	61.9		7
II	60.1		7
	52		3
II	50		2
II	25		10
II	21		9
II	19		9
II	1 671		10
III	12		8
III	06		8
III	1 384		5
	19?		6
	10?		6
II	1 211.93		1
II	1 191.83		2
II	1 190.07		2
III	856.80		3
III	854.98		3
III	696.23		2
III	695.82		3

As (13, 23, 59, 90, 91, 118, 138, 154, 280)

λ	A	S	G
6 170		6	
10		6	

As.—(*Continued*)

λ	A	S	G
6 023		6	
5 837.9			6
5 731.8		1	6
5 684.8		1	7
57.0		1	8
51.3		10	10
20.6		1	10
5 558.1		10	8
5 497.8		10	7
96.9		5	6
5 331.3		8	7
5 205.3		1	6
5 182.2			7
61.1		7	7
07.6		8	8
05.5		8	8
4 985.4		5	9
15.3			7
4 888.6		2	8
11.8		1	6
02.1		1	6
4 799.5		1	6
87.1		1	6
30.7			8
07.6			7
4 672.5			7
29.9			7
19.4			7
07.3		2	5
02.5			7
4 590.8			7
52.2		2	7
49.0		2	9
43.6			7
39.8		3	8
28.4			7
15.9			7
4 494.4		3	7
74.4		4	8
66.4		1	7
61.1			8
58.6		2	7
31.6		4	8
27.2			7
20.9			7
13.5			7
12.0			7
4 371		5	7
52.9			8
52.1		5	7
36.7		5	7
24.0			7
15.7		1	7
02.1			8
4 299.4		3	6
43.1			7
28.2		2	7
21.0			7
07.8		2	7
4 197.5		3	7
90.2		2	7
57.5			7
4 082.4			7

As.—(*Continued*)

λ	A	S	G
4 065.4		2	7
62.6			7
37.0		6	6
06.2		3	6
3 948.6		3	6
31.1		2	7
22.5		10	7
3 842.9		4	7
3 787.2		3	6
3 671.7			6
3 551.6			5
13.0			6
3 255		2	6
3 180.6			6
26.9			6
I 19.6	4	7	5
16.5		3	7
I 3 075.32	2	5	5
I 32.84	4	8	6
03.8		2	6
I 2 990.99	2	4	5
59.6		7	6
26.2		1	6
I 2 898.73	4R	6	6
I 60.46	4R	8	7
30.4		4	8
I 2 780.23	8R	10	8
I 45.00	6R	5	7
2 602.9		2	6
2 492.91	2	5	4
56.52	4R	7	5
37.22	1	5	3
I 2 381.20	4R	5	5
70.77	4R	5	4
69.67	4R	5	4
I 49.84	10R	6	4
I 2 288.14	10R	3	
71.39	4	1	
28.7	2	1	
06.0	2		
05.2	2		
2 192.1		2	
83.0	1	1	
65.5	4	2	
44.2	4	1	
34	2	2	
13	2	3	
2 074		12	
31		10	
1 972		4R	
36		5	
1 890		4R	
1 742.9		20	
33.0		15	
00.2		10	
1 287		10	
67		40	
08		30	
1 171		15	
06		10	
1 093		20	
81		50	
09		10	

As.—(*Continued*)

λ	A	S	G
1 001		10	
984		10	
63		10	
56		8	
52		8	
26		8	
878		8	
73		8	
27		5	
529		1	

Au (18, 24, 59, 60, 62, 75, 90, 91, 111, 136, 154, 222)

λ	A	S
I 7 510.7	5	
I 6 278.2	4	3
I 5 957.0	2	3
I 5 863.0	2	3
I 37.41	4	6
5 759.9		3
I 5 655.8	2	2
5 230.30	2	3
I 5 064.61	2	2
I 4 811.61	3	2
I 4 792.62	8	6
I 4 607.4	4	2
I 4 488.25	4	4
I 37.29	4	3
I 4 315.1	1	3
I 4 241.82	1	3
I 4 084.14	1	2
I 65.08	6	8
52.8		5
I 40.95	2	2
16.1		4
I 3 909.39	2	2
I 3 897.89	4	8
74.7		2
53.6	1	2
25.7		3
04.0		5
3 706.8		4
3 649.1		3
33.25		3
14.0		2
3 586.7		5
53.55	2	4
I 3 320.16	3	2
I 08.31	2	2
3 230.61	3	3
I 04.74	4	3
I 3 194.71	4	2
I 22.79	6R	8
22.5		5
17.0	4	1
3 033.4	2U	2U
I 29.21	6v	5
2 995.0		5
90.3		5
73.25	2U	
70.41	2	

Au.—(*Continued*)

λ	A	S
2 963.77	2	1
54.4		4
32.19	5	4
13.5	4	10
07.1		4
05.90	6	3
I 2 891.95	4	2
I 83.45	4	3
38.0		3
25.4		4
22.7		3
19.98		8
02.21		10
2 780.83		3
I 48.26	6R	4
I 00.88	4	3
I 2 688.70	4	3
88.2		3
87.6		3
I 75.95	10R	10
I 41.50	4	4
I 2 590.07	4	2
I 44.2	4	2
I 10.51	4	2
03.3		5
I 2 427.98	10R	10R
I 2 387.77	4	3
I 76.25	3	2
I 64.58	4	2
I 52.67	4	3
40.22		3
14.67		3
04.80		4
2 291.51		3
83.3		3
42.7		3
29.0		3
01.3		3
2 110.7		2
2 082.0		3
00.6		3
1 977.3		3
I 51.2		3
21.0		4
I 18.9		4
03.9		2
1 889.8		2
86.3		4
I 79.1		3
71.1		3
61.1		3
50.1		2
45.7		3
22.4		4
02		5
1 795		5
84		5
67		3
40		4
27		3
26		4
20		3
1 699		3

Au.—(*Continued*)

λ	A	S
1 694		6
73		6
59		3
39		3
29		3
22		4
00		3
1 590		3
62		3
34		3
00		4d
1 488		4d
35		4
02		2
975		20
864		5
854		4
832		5
458		1

B (28, 33, 36, 48, 80, 90, 91, 124, 191)

λ	A	S
II 3 451.2		10
I 2 497.733	10R	10R
I 96.778	9R	9R
2 266.9		2
66.3		2
I 2 089.6		2
I 88.8		1
III 67.9		2
III 66.4		
I 1 826.41		1
I 25.87		
II 1 624.4		8qn
III 758.68		3
III 758.47		
III 677.16		5
III 677.01		

Ba (59, 60, 62, 74, 75, 78, 90, 91, 135, 148, 163, 174, 224, 252, 258)

λ	A	S
I 30 934	3	
I 687	2	
469	2	
29 791	4	
I 224	5	
27 751	3	
26 221	2	
I 25 516	5	
23 255	3	
22 313	2	
221	2	
I 21 477	2	
I 20 712	4	
19 988	3	
075	2	
18 204	2	
17 182	1	
065	1	

Ba.—(*Continued*)

λ	A	S
I 15 000	4	
14 325	3	
211	3	
160	3	
078	4	
13 957	2	
811	4	
I 207	4	
057	1	
12 815	1	
554	3	
II 084	5	
11 978	2	
886	5	
608	2	
I 304	2	
116	2	
016	4	
10 692	2	
II 651	8	
474	6	
I 326		
I 273	5	
234	6	
I 189	1	
II 034	6	
002	3	
I 9 832	7	
713	2	
611	10	
527	10	
370.1	3	
219.7	2	
189.4	2	
8 915.00	4	
860.96	4	
I 799.7	2u	
654.03	4	
582.1	4	
567.6	3	
559.91	10	
210.32	10	
147.8	2	
120.5	3	
I 7 911.35	6	
I 905.772	7	
839.577	5	
780.500	8	
672.099	7	
642.9	5	
488.095	5	
459.7	5	
417.55	4	
I 392.44	6	
280.314	8R	
228.815	5	
I 195.262	6	
II 120.30	6	
I 059.96	8R	
6 865.69	5	
I 693.86	6R	2
I 675.29	6R	2
I 595.35	7R	3
I 527.323	8R	3

Ba.—(*Continued*)

λ	A	S
I 6 498.77	8R	4
II 496.91	10R	10R
482.93	7R	3
I 450.85	7	3
I 341.70	7R	3
II 141.74	10R	10R
I 110.80	8R	5
I 063.16	8R	4
I 019.49	7R	3
I 5 997.102	7R	3
I 71.714	10	3
I 07.6	6	2
II 5 853.7	8R	5
I 26.30	7R	4
05.71	5R	2
00.34	7	2
I 5 777.7	10R	5
5 680.17	5	1
I 5 535.53	10R	6
I 19.11	8R	5
I 5 424.63	7r	3
II 4 934.10	10R	10R
I 02.88	4r	
II 4 899.96	8	10
I 4 726.46	8r	5
I 00.45	6r	1
4 691.63	7R	4
I 73.61	7v	2
I 28.83	5v	1
I 19.98	5r	1
4 599.75	6R	2
79.66	8R	8
73.88	6R	4
II 54.037	10R	10R
II 24.95	8	10r
23.25	8r	3
05.94	8	5
I 4 493.64	5v	2
I 88.97	7v	2
31.91	7	6
02.55	8	6
4 350.38	8	5
I 32.91	4v	1
I 23.00	4v	1
I 4 283.12	8	8
II 4 166.04	5r	10r
32.44	5	3
II 30.68	8R	10R
I 3 993.40	8R	6
I 37.88	5	3
I 35.72	7r	6r
I 09.92	6r	6r
3 892.65	5	
II 91.78	8r	8R
89.32	5	2
3 630.65	8r	2
I 3 579.7	6r	2
I 47.7	4u	
I 44.7	6r	
I 25.0	6r	
I 01.12	8R	2
I 3 421.5	10	
I 21.0		
I 20.3		

Ba.—(*Continued*)

λ	A	S
I 3 377.4	8	
I 77.0		
I 56.9	6r	
I 3 262.4	3R	
I 3 071.60	8R	6R
I 2 785.26	6r	
II 71.4	2	3r
I 02.65	6r	2
II 2 647.29	4	4
II 34.80	5	8r
I 2 596.68	6r	
II 28.51		6r
II 2 347.58	5	7
II 35.25	6R	10R
II 04.22	6R	8R
II 1 869		5
II 1 694		6
74		4
1 554		3
04		4
1 415		3
1 331		2

Be (35, 90, 91, 230, 273)

λ	A	S
23 110	6	
097		
22 239	2	
21 897	2d	
560	3	
17 571	2	
16 794	2	
15 951		
400	6	
393		
013	3	
006		
14 904	3	
13 227	6	
12 355	6	
329	4	
141	7	
10 674	4	
283	5	
II 5 274.28		4
II 4 674.55		8
4 572.69	8	1
II 4 362.21		7
I 3 322.303	8	2
I 22.042	8	2
I 21.969	8	2
II 3 275.57		5
II 3 198.01		4
II 31.972	9	5
II 31.324	9	10
II 3 047.86		4
I 2 651	10	10s
I 2 494.720	7	3
I 94.575	7	3
I 94.532	7	3
I 2 351.50	6	

Be.—(*Continued*)

	λ	A	S
	2 348.62	8R	3
I	2 175.72	10	
I	2 056.71	4	
II	1 776.339		8
II	76.118		6
II	1 512.451		10
II	12.303		8
II	1 036.32		3

Bi (13, 59, 74, 75, 78, 90, 91, 138, 154, 170, 200, 223, 276)

	λ	A	S
	25 554	1	
	14 332	3	
	12 691	3	
	167	4	
	11 995	1	
	711	10	
	556	1	
	073	1	
	10 540	1	
	302	2	
	106	2	
	9 829	2	
	9 657.2	10	
	9 342.6	4	
	9 058.6	2	
	8 907.8	2	
	8 761.5	3	
I	8 754.9	2	
	8 627.9	1	
	8 579.7	1	
	44.5	2	
	01.8	1	
	8 210.8	10	
	7 840.3	2	
	38.7	3	
	7 502.3	2	
	7 441.3	1	
	7 335.0	1	
	7 036.2	2	
	6 991.1	4	
	6 809.1		7
	6 600.1		7
	6 497.5		4
	76.2	3	
	75.5	3	
	6 134.85	5	1
	28.1		4
	5 861.14		4
	5 742.55	6	
	5 599.41	3	
	52.24	8	3
	5 209.28		10
	5 144.50		6
	24.4		4
	4 797.5		3
	33.8	2r	
	29.9		3
	22.7	8	8
	22.5	10	8
	22.2	10	5
	4 561.15		8

Bi.—(*Continued*)

λ	A	S
4 340.6		4
28.6		3
08.56	4	2
08.20	4	2
02.13		10
4 259.64		10
4 121.85	6	4
21.52	6	4
4 079.22		10
3 888.22	2	1
87.94	2	1
3 792.9		8
3 695.53		8
3 596.11	3R	4
10.85	6R	5
3 405.23	2R	1
3 397.21	5R	2
3 076.67	3	2
67.73	9R	6R
24.64	8R	4R
2 993.34	9R	4
89.04	9R	5R
38.31	10R	8R
2 897.98	10R	5R
09.63	8R	2
2 780.52	7R	4
30.50	5Rd	2R
2 696.76	6Rd	4R
27.93	8 R	4
2 524.52	7R	2
15.68	6R	1
2 489.4	5U	1
30.5	2u	
00.89	8R	7
2 328.2	2u	
09.3	4U	
2 276.57	5R	2
30.62	8R	4R
28.25	6R	2R
14.1	3	1
03.1	4u	1
2 189.59	6R	
77.3	6R	1
64.1	4R	
56.9	4R	
53.5	4R	
52.9	7R	
44.4		2
43.6		2
34.4	8R	1
33.6	7R	
13.8	3	
10.3	8R	2
2 061.7	8R	3
1 973.2		3
59.6		3
02.5		1
1 823.5	3	5
1 791.7	4	4
87.1	3	4
76.7	3	4
1 533.7	5	3
1 346		10
17		15

Bi.—(*Continued*)

λ	A	S
1 306		10
1 051		10
45		10
967		3
791		2
670		1

Br (25, 86, 91, 104, 147, 195, 268)

λ	S	G
6 682		2
31.8		5
6 560.0		4
6 350.8		10
6 149.7		10
23.3		3
18.7		4
5 940.6		4
5 852.2		5
30.8		7
5 719.0		4
11.0		4
5 657.6		4
00.7		4
5 589.9		8
36.3		4
5 490.4		7
88.8		6
66.2		5
35.1		5
25.0		5
22.8		7
5 396.5		5
32.0		10
04.1		7
5 272.7		4
38.3	2	8
5 183.9		4
82.4	3	7
64.4		5
5 054.7		4
4 979.77		4
30.6	1	5
28.7	1	5
4 848.80	1	6
16.72	8	8
4 785.48	10	10
80.33		6
76.43	2	7
67.1	2	8
66.07	2	5
42.70	3	8
35.47		5
19.76	3	8
04.83	10	10
4 693.30	5	3
78.70	8	8
72.58	1	6
52.00	1	6
22.7	3	8
14.6		6

Br.—(*Continued*)

λ	S	G
4 601.4		5
4 575.77		6
42.93	2	8
38.75	1	5
29.80		5
25.6		8
13.47	1	5
4 490.48		5
77.78		10
72.64		8
41.74		8
25.13		5
4 365.58	4	8
4 291.38	2	6
36.85		6
23.85		6
4 193.45	1	6
79.62	1	8
75.76		5
40.22	1	6
35.64		5
4 024.04		5
08.78		6
07.30		5
3 986.53	1	8
80.43		10
80.01		5
68.65		5
55.35		8
50.60	1	7
39.70	2	5
35.16		6
29.57		6
24.09	2	8
23.36		6
20.68		6
19.6		6
14.26	1	10
3 891.64	1	8
71.23		6
57.21		6
34.71		6
3 794.00	3	4
3 693.5	3	
3 562.4	10	
40.1	8	
17.4	5	
06.5	5	
3 417	5	
3 396.9	4	
33.0	5	
3 282.1	3	
3 168	3	
3 074	4	
20.8	4	
2 968	4	
26	5	
2 892	3	
72	3	
2 660	3	
2 594	3	
57	4	
41	4	
22	4	

Br.—(*Continued*)

λ	S	G
2 389.8	3	
86.8	3	
1 633.6		10
1 582.4		8
76.5		6
75.0		9
40.8		6
31.9		7
1 488.6		8
1 384.6		8
1 251.8		4

C (27, 32, 33, 60, 79, 90, 91, 98.1, 154, 166, 167, 190, 193, 262, 262.1, 287)

λ	A	S	G
II 7 236.19			8u
II 31.12			6u
II 6 582.85			8
II 78.03			10
III 4 652.68		7	
III 51.46		2	
III 48.70		3	
II 4 267.27			10u
II 67.02			8u
II 3 920.773			8
II 19.061			6
II 2 992.63			4
II 2 837.602			8
II 36.710			10
II 2 747.31			6u
II 46.50			4u
I 2 478.3	10	10	10
III 2 297.59	2	10	
III 1 930.98	5	7d	
1 657	6	6qr	
I 1 561.3	5	5	5
IV 50.9		3	
1 335.7	10	} 10	
34.5	10		
29.6	8	} 4	
29.1	8		
23.7	7	7	
1 176	10	15qn	
II 1 036.8		} 10	5
II 36.2			5
I 10.1	9	10	
III 977.02		12	
II? 904	4	10qr	
II 858.2	8	8	8
II 687.1	8	7	8
651	2	6d	
II 636.2		2	
II 594.9	4	5	
574.4		6	
II 560.5		2	
II 543.4		2	
III 538.4		7	
II 533.9		1	
III 459.7		6	
372		1	
313		1	

Ca (1, 61, 74, 78, 90, 91, 119, 154, 158, 163, 170, 174, 181, 192, 203, 250)

λ	A	S
I 22 656	4	
I 625	3	
I 610	1	
I 19 947	1	
I 936	3	
I 918	1	
I 865	4	
I 857	4	
817	1	
I 777	6	
I 507	3	
I 453	5	
I 311	4	
16 433	1	
I 200	3	
I 162	2	
I 145	2	
13 038	3	
I 12 822	5d	
I 10 345	10	
9 695	7	
9 547	7	
9 251	3	
II 8 662.1	9	
II 8 542.1	10	
II 8 498.0	8	
7 610	6r	
I 7 326.12	8	
7 202.18	8	
7 148.18	10	
I 6 717.7	8	2
I 6 572.75	2	1
I 6 499.64	5	4
I 93.762	8	5
I 71.68	5	5
I 62.57	6R	6
55.57	3	2
49.82	5	3
I 39.060	10R	8
I 6 169.60	7	3
I 69.08	4	3
I 66.49	4	2
I 63.80	4	2
I 62.20	10R	8R
I 61.32	5	2
I 22.24	10R	10R
I 02.73	8R	8R
5 867.62	4r	
57.49	10	10
5 602.84	8	5
I 01.26	8	4
5 598.46	10	8
I 94.47	8	6
90.10	10	6
88.74	10	10
81.96	8	4
I 12.93	8	2
5 349.46	10	5
I 5 270.27	10	10
65.55	8	8
I 64.23	6	5
62.23	6	5

Ca.—(*Continued*)

λ	A	S
5 261.70	6	5
I 60.39	4	3
I 5 188.84	6	5
41.65	8r	3
I 4 878.17	10r	8r
I 4 685.2	4v	1
I 4 585.91	2	8
I 85.84	6	
I 81.45	8	6
I 78.57	8	5
I 26.98	6	5
4 499.90		10
I 56.62	4	5
I 55.880	8R	8
I 54.780	10R	10R
I 35.682	8R	8
I 34.964	10R	10R
I 25.444	10R	10
I 4 355.2	6u	2
I 18.645	8R	8R
I 07.74	8R	8R
I 02.527	10R	10R
I 4 298.987	6	8R
I 89.362	8R	8R
I 83.003	8R	8R
I 40.44	4	2
I 26.728	10R	10R
I 4 098.6	4r	2r
I 3 973.7	6r	3r
II 68.473	10R	10R
I 57.07	6r	2
I 48.91	4r	1
II 33.673	10R	10R
I 3 875.7	3	
II 3 736.905	6	10R
II 06.03	6	8r
I 3 644.76	5	
I 44.39	10	4
I 30.96	5	1
I 30.73	6	1
I 24.10	6	1
I 3 487.61	6r	1
I 74.78	4r	
I 68.48	4r	
I 3 361.91	6v	1
I 50.19	6v	1
I 44.49	5v	
I 3 286.1	5	
I 25.8	4r	
I 15.1	3v	
II 3 181.3	4	10
II 79.34	6	10R
II 58.87	8	10R
19.66		8
I 3 009.21	2	2
I 06.85	4	4
I 00.87	4	2
I 2 997.31	3	2
I 94.95	3	2
24.33	8	
2 899.78	9	
2 493.00	7	
I 2 398.58	8R	1R
I 2 275.5	1	4R

Ca.—(*Continued*)

λ	A	S
II 2 208.7	3	3
II 2 197.8	3	3
II 12.7	2	3
II 03.2	2	3
2 040	4	
35	4	
II 1 851.3		7
II 43.7		6
II 40.2		10
II 38		9d
II 15.0		8
II 07.8		7
1 667		5
1 562		4
II 55		8d
II 53		7
II 1 434		6
902		10
840		6
832		10
718		6
688		5
669		6
655		6
537		5
410		6
404		6

Cb* (78, 90, 91)

λ	A	S
6 828.14	4	
6 723.66	6	1
6 677.34	8	1
6 544.67	6	1
6 430.50	8	1
5 983.26	7	2
00.62	10d	2
5 866.5	6	3
38.66	8	5
19.47	6	3
5 787.53	6	2
29.2	6	2
5 671.1	7	1
65.57	6	3
64.72	6	2
5 551.38	6	2
5 437.29	7	2
5 350.72	7	3
44.15	10	5
5 276.20	10	3
71.53	9	3
5 180.30	6	2
64.36	7	2
60.33	6	3
34.73	5	2
5 095.29	10	3
78.95	8	3
39.04	6	2
4 989.0	5	2
24.84	3	8

* Columbium = Niobium.

Cb.—(*Continued*)

	λ	A	S
	4 816.33	7	1
	10.57	6	3
	4 733.88	5	3
	13.48	5	3
	08.26	7	4
	4 675.38	10	8
	72.10	10	9
	63.83	9	4
	48.94	7	3
	30.12	10	10
	06.76	10	10
	4 581.64	10	5
	73.09	10	5
	46.83	10	4
	23.40	8	3
	4 447.22	10	3
	37.23	10	8
	10.22	10	3
	4 377.90	10	4
	51.60	10	3
	31.42	10	3
	26.37	10	3
	01.10	10	5
	4 299.63	8	4
	62.10	8	3
	29.15	10	3
	17.95	10	3
	14.74	10	3
	05.32	10	3
	4 192.07	10	3
	90.91	10	4
	68.13	10	5
	64.66	10	5
	63.64	10	10
	52.63	10	5
	39.74	10	4
	37.13	10	4
	29.97	10	3
	23.85	10	4
	00.97	10	6
	4 079.73	10	6
	58.97	10	10
	32.55	10	3
	3 966.23	10	3
	37.47	10	3
	14.71	10	3
	3 818.92	1	8
	10.48	10	3
	02.98	10	4
	3 798.11	10	4
	91.24	10	4
	90.14	10	3
	87.08	10	3
	59.57	10	3
	42.41	10	3
	40.80	10	5
	39.82	10	3
	26.24	10	3
	13.05	10	3
	3 697.84	10	3
I	3 580.27	10	3
I	75.85	10	2
I	63.53	10	2

Cb.—(*Continued*)

	λ	A	S
I	3 554.62	10d	2
I	37.50	10	2
I	35.30	10	3
I	10.30	3	8
	3 498.62	10	2
	3 358.38	10	
	41.95	10	4
II	3 236.44	3	10
II	25.47	5	10
II	3 194.95	5	10
II	63.37	5	10
II	30.78	8	10
II	3 094.19	10	10
II	2 950.91	6	10
II	41.57	4	8
II	27.82	8	10
II	2 697.07	3	7
	2 584.03	2	6

Cd (13, 16, 59, 74, 75, 81, 90, 91, 132, 154, 176, 204, 205, 206, 207, 247, 251, 273, 276, 284, 287)

	λ	A	S
I	39 086		
I	16 482	6	
I	432	6	
I	402	2	
I	15 711	7	
	258	7	
I	154	10	
I	14 849	2	
I	473	8	
I	354	8	
I	327	10	
I	13 979	10	
I	11 630	2	
I	268	4	
I	10 394.6	10	
I	8 200.1	1u	
I	7 399	5	
I	82.3	2u	
I	46.0	1u	
I	6 777.7	2u	
II	25.83		15
II	6 464.98		10
I	38.4696	10	10R
II	6 359.93		10
I	29.94	5	
I	25.1	5	1
I	6 116.12	3	1
I	11.5	3	
I	6 099.1	5	
I	31.4	3	
	5 637.3	5	
I	04.7	2	
I	5 598.8	3	
	5 497		10u
II	5 381.82		10
II	78.12		10
	78	3	
I	39	2	
	38.5		10

Cd.—(*Continued*)

	λ	A	S
II	5 337.49	3	25
I	5 297.7	3	
I	5 085.823	10R	10
II	4 881.73		10
I	4 799.912	10R	10
I	4 678.151	10	10
	4 415.68	1	6
II	12.31		10
	4 245.6		4
	16.9		6
	4 191.6		4
II	34.78		15
	27.0		4
	4 094.8		4
	57.5		5
II	29.08		10
	3 988.2		4
	77.3		5
	76.6		5
	40.3		5
	3 852.1		3
I	3 729.06	4r	
I	3 614.4	7	7
I	12.875	8R	9
I	10.510	10R	10R
II	3 535.67		20
II	3 495.36		15
I	67.656	8R	10
I	66.200	10R	8R
II	17.40		10
I	03.653	10R	10
	3 298.97	4	4R
I	61.05	10R	7
I	52.525	8r	6u
II	50.29		25
	3 185.53		5
I	33.167	2r	5r
	29.23		5u
	3 095.5		5r
I	80.828	8r	3r
I	2 980.622	8R	6
I	2 881.24	4R	3U
I	80.78	8R	6
I	68.3	6r	3r
I	36.92	8R	6U
I	2 763.9	6R	3U
II	48.58		10
I	12.6	6r	1u
I	2 677.6	8d	3u
I	39.50	6R	1u
II	2 573.04	4	10
I	53.6	4r	
	2 469.76		4
	2 329.27	8R	6
II	21.15	1	7
II	12.88	4	10R
	06.63	4R	3
I	2 288.03	10R	10R
	67.47	4R	2
II	65.03	4R	10R
	39.86	6R	3
II	2 194.62	1	4R
II	44.39	4R	6R

Cd.—(*Continued*)

	λ	A	S
	2 062.0		5
	55.3		3
	04.2		5
	1 995		3
I	42		2
	39		2
	21.8		2
	00.7		6
	1 873.6		15
	56.0		15
	44.5		10
	1 773.1		6
	68.8		6
	47.9		6
	07.5		8
	1 628.7		6
	1 514		20
	1 472		8
	66		8
	62		20
	1 397		20
	69		20
	847		10
	396		1

Ce (6, 61, 78, 90, 91, 145, 151, 154, 155)

λ	A	S
8 772.08	3	
8 647.59	2	
12.62	2	
8 560.60	2	
8 495.64	3	
8 396.20	2	
71.90	2	
63.82	2	
55.32	2	
10.22	2	
00.58	2	
8 261.03	2	
45.10	2	
34.12	3u	
8 171.32	2	
8 025.59	2	
02.66	2	
7 860.54	2	
59.05	2	
35.81	2	
7 797.73	2	
7 689.13	2	
7 397.78	2	
29.92	2	
7 252.72	3	
38.38	2	
7 150.21	2	
7 086.31	3	
61.69	3	
30.98	2	
6 999.87	2	
86.00	2	
24.80	3	
6 899.07	2	
98.49	2	

Ce.—(*Continued*)

λ	A	S
6 774.27	2	
04.40	3	
00.67	3	
6 665.65	3	
52.75	3	
28.90	3	
06.87	3	
6 555.65	3	
13.63	3	
6 473.69	3	
67.40	3	
66.89	3	
58.06	3	
6 393.06	3	1
71.13	4	
43.98	4	1
10.03	3	
00.22	3	
6 295.58	3	
72.05	4	2
32.47	3	1
28.98	4	1
09.00	3	
6 186.16	3	
23.66	4	
6 098.35	4	1
69.48	3	
57.99	3	
43.39	5	2
24.18	5	
13.41	5	
5 975.87	4	
40.86	4	1
34.40	4	
28.34	4	
10.00	5R	
5 871.58	3	
62.49	4	
38.12	4	1
12.9	5	
04.42	4	
5 788.15	4	
73.12	4	
68.94	4	1
43.54	5	
25.84	4	
19.04	5	
5 699.22	5	1
96.99	5	1
77.74	4	1
69.96	5	1
55.14	5	1
14.73	3	
01.28	5	1
5 556.27	4	1
12.06	8	3
5 472.27	5	3
09.23	6	3
5 393.39	7	3
30.53	5	2
5 274.23	5	3
11.91	4	
5 191.63	5	1
87.44	6	2

Ce.—(*Continued*)

λ	A	S
5 117.14	4	1
5 079.68	5	2
44.02	4	1
22.85	4	1
4 971.50	4	2
4 893.93	3	2
82.44	4	3
4 773.93	4	3
37.24	4	3
25.09	4	2
14.01	4	3
4 684.61	4	3
54.28	4	2
28.15	10	10
06.41	4	5
4 593.93	10	10
72.28	10	10
62.35	10	10
39.74	10	5
28.47	10	5
27.35	10	5
09.18	4R	3
4 471.24	10	5
60.21	10	10
49.33	9	4
18.78	7	5
4 396.58	3R	2
91.66	8	8
82.17	8	5
75.18	8	3
49.79	8	4
37.76	9	4
20.73	8	3
06.73	8	4
4 296.68	9	8
89.94	9	6
55.79	8	3
48.67	8	6
22.62	10	5r
4 186.60	10	10
65.61	9	10
52.01	8	10
49.94	10R	10
37.64	9	10
33.82	10	10
06.89	5R	3
4 083.24	10	5
73.49	9	4
40.76	9	8
12.40	10	10
3 999.25	10	6
93.83	9	4
92.39	9	3
56.29	9	3
52.58	9R	8r
42.75	10	5
3 890.00	8	3r
78.37	9	2
75.04	6R	2
53.16	8	2
01.53	10	8
3 786.63	8	3
64.12	8	3r
16.36	9	3

Ce.—(*Continued*)

λ	A	S
3 709.29	8	3r
3 679.42	6	2
67.97	9	3
55.85	10	3
23.84	7	3
13.70	10R	2
3 577.45	8	4r
60.82	8	4r
39.08	7	2
17.38	7	2
3 488.55	7	1
85.06	8	2
76.84	6	2
42.38	7	1
26.20	8	1
3 377.13	7	2
66.56	7	1
44.76	7	2
04.84	7	1
3 285.23	6	1
72.25	7	2
34.17	7	1
21.17	7	1
01.72	7	1
3 194.83	7	1
71.63	6R	1
46.40	6	1
03.38	6	1
3 063.00	6	2
51.98	5	1
17.18	4	1
2 976.90	4	1
2 896.75	4	
33.30	4	
2 791.42	4	
2 696.06	4	
51.02	4	1
1 373		20
32		20
830		20
741		5
399		1

Cl (2, 29, 31, 32, 85, 91, 125)

λ	S	G
5 634.9		1
5 457.1		3
44.2		3
43.4	1	5
23.2	2	6
5 392.1	2	4
21.3	1	4
17.8	1	3
5 078.2	2	4

Cl.—(*Continued*)

λ	S	G
4 904.7	2	4
4 896.7	2	5
19.4	10	9
10.0	10	9
4 794.5	10	10
81.3	3	5
68.6	2	4
4 601.0		4
4 572.6	1	5
26.3		5
4 490.0	1	3
75.3		4
69.4		5
38.6		4
03.4		5
4 389.8		8
87.6		5
79.9		8
73.0	2	6
71.6		5
69.5		6
63.3		8
43.7	5	10
36.3	2	5
23.4		6
07.6	3	6
04.1	1	4
4 291.8	2	5
53.4	2	9
41.3		8
34.0		5
26.4		7
09.7		5
4 158.0	2	4
32.5	10	3
04.8		4
4 032.2		5
3 914	2	5
3 868.7	1	6
61	5	10
51.5	3	8
51.0		10
45.7	2	8
45.4		8
43	2	5
33.4	2	8
27.7	2	5
20.3	1	5
05.2	2	6
3 798.8	2	5
81.2		5
50.0		5
3 650.1	1	4
02.1	4	2
3 522.0		6
3 392.8		8
53.3	3	7
40.3	3	8
29.0		8
20.5	2	8
15.3	1	6
3 289.7	1	6
59.2	2	4
3 191.4	3	7

Cl.—(*Continued*)

	λ	S	G
	3 139.2		6
	3 076.6		7
	71.3	1	6
	63.0		6
	2 996.5		5
	2 782.4		6
	10.37		6
	2 691.49		6
	88.03		6
	85.40		5
	84.75		5
	65.5		6
	61.5		4
	58.7		4
	24.72		6
	20.07		6
	16.99		8
	11.4		5
	09.50		7
	03.5		6
	01.2		5
	2 580.7		8
	77.1		6
	32.5		7
	19.5		6
	2 471.1		4
	48.6		4
	34.5		5
	03.2		5
	2 370.4		4
	59.6		4
	2 283.9		4
	51.5		5
	51.0		5
	2 093.4		4
	87.1		5
	1 821.9		2
	1 577.7		2
	47.2		3
	1 145.0		2
	1 070.9		4
	14.9		4
	08.6		4
	984.8		4
	60.4		6
	888.0		4
	40.9		6
VII	13.00		2
VII	00.70		3
	787.8		4
VI	30.31		4
	12.6		4
	663.2		4
	53.7		4
V	39.24		5
V	35.31		6
V	33.18		6
V	29.33		6
	586.9		4
	74.3		4
	61.5		4
	56.4		4
IV	38.08		3

Co (12, 16, 24, 54, 75, 90, 91, 153, 154, 177, 216, 226, 267)

λ	A	S
19 779	3	
18 274	2	
176	3	
17 080	3	
005	5	
16 574	3	
447	2	
388	3	
257	5	
133	5	
15 210	2	
14 958	3	
681	2	
611	4	
559	2	
062	4	
11 895	1	
634	2	
453.4		
340.8		
293.5		
275.5		
10 366.6		
284.6		
272.9		
236.4		
213.3		
210.8		
206.1		
189.2		
020.7		
9 597.9	2	
44.5	2	
9 357.0	10	
9 095.4	6	
37.9	8	
8 958.5	6	
26.2	10	
04.7	8	
8 870.8	4	
50.7	10	
35.2	8	
19.2	10	
8 575.3	4	
8 378.4	7	
72.8	10	
8 299.0	5	
69.4	8	
08.7	8	
8 193.1	8	
52.0	6	
16.4	7	
8 094.0	10	
66.5	7	
56.0	8	
43.3	8	
29.3	7	
22.2	7	
07.3	10	
7 987.4	7	
26.6	8	

Co.—(*Continued*)

	λ	A	S
	7 908.8	10	
	7 871.4	6	
	69.9	6	
	55.9	7	
	40.1	7	
	38.2	8	
	7 734.3	6	
	12.7	9	
	7 610.3	6	
	7 590.6	6	
	54.0	8	
	7 457.4	8	
I	17.4	8	
	7 388.7	7	
I	54.6	6	
	7 285.3	7	
	7 193.60	8	
	59.16	8	
I	54.7	8	
	34.33	8	
I	7 084.97	10	
	54.04	8	
I	52.85	10	
	27.82	8	
I	16.6	10	
	6 937.8	7	
	6 872.38	7	2
I	14.96	10	1
I	6 771.05	10	2
I	6 678.81	6	
	32.44	6	2
	17.30	10d	1
	6 595.90	6	3
	63.40	9	3
	6 490.32	7	1
	77.89	9	
	55.02	10	5
I	50.23	10	6
	29.89	7	
	17.80	8	1
	6 395.19	7	1
	47.79	10	1
	20.35	10	2
I	6 282.65	10	4
	71.40	10	
	57.61	10	3
I	31.02	7	3
	11.13	8	1
I	6 188.98	8	3
	22.68	10	2
	07.93	7	1
I	6 093.14	6	2
	86.66	7	2
	82.46	10	5
	49.06	10	2
	07.63	8	2
	06.30	8	2
	00.71	8	1
	5 991.88	10	5
I	84.19	10	2
	46.51	8	1
	15.53	8	3
	5 890.48	7	2
	30.06	7	

Co.—(*Continued*)

	λ	A	S
	5 647.22	8	1
I	5 590.73	8	1
I	30.77	8	1
I	5 483.35	10	2
	54.55	9	1
	44.56	8	1
I	5 369.59	7	1
	62.76	8	1
	53.48	7	2
I	52.05	8	2
	43.38	7	2
	42.68	8	2
I	5 280.63	5	1
	66.49	6	1
I	30.21	5	1
I	12.70	5	1
	5 176.07	6	
	33.45	5	1
I	22.76	5	1
I	4 971.95	6	
I	4 867.88	8	8
I	40.28	8	8
I	13.49	8	10
I	4 792.87	7	7
I	49.69	8	3
I	4 682.36	7	3
I	63.41	8	4
I	29.38	8	4
	4 596.90	6	3
	94.62	6	3
I	81.62	8	8
	65.61	7	7
	49.664	6	5
I	30.97	7	10
I	4 469.57	8	5
	4 339.64	5	3
	4 252.30	5	2
I	4 190.71	7	4
	60.7	1	8
I	21.327	10R	10R
I	18.78	8R	10
I	10.54	9	10
I	4 092.40	8R	8
I	86.32	8	9
I	66.39	7R	5
I	45.40	8R	5
I	20.898	7R	5
I	3 997.905	7R	10
I	95.312	8R	10
I	74.731	5R	4
I	57.935	6R	4
I	41.736	5R	4
I	35.974	6R	10
I	3 894.085	9R	10
I	76.84	8R	5
I	73.117	9R	10
I	61.168	7R	10
I	45.478	10R	10
I	42.06	6R	10
	3 755.450	6R	4
I	45.50	6R	10
	32.398	8	7
I	04.06	8	7
	3 683.054	8	8

Co.—(*Continued*)

	λ	A	S
	3 676.555	8	6
	39.44	10	2
I	27.81	8R	4
I	02.083	5R	4
I	3 587.19	8R	10
I	75.36	6R	5
I	74.96	5R	4
I	69.38	7R	10
I	64.95	5R	4
I	50.60	5R	3
I	33.361	6R	4
I	29.814	8R	6
I	29.037	4R	3
I	26.853	9R	6
I	23.438	4R	5
	21 57	5R	5
I	20.087	4R	3
I	18.352	6R	7
I	13.483	4R	4
I	12.642	4R	6
I	10.419	4R	4
I	09.847	4R	5
I	06.316	6R	8
I	02.282	5R	6
I	3 495.683	6R	5
I	89.404	5R	7
	85.345	7	3
I	74.019	9R	8
I	65.794	6R	5
I	62.808	6R	5
I	53.514	6R	10
I	49.445	6R	5
I	49.172	6R	5
I	43.646	3R	6
I	33.041	6R	6
I	12.335	4R	4
I	09.177	4R	6
I	05.120	7R	10
I	3 395.379	10R	5
I	88.175	9R	5
I	85.228	9R	4
	77.06	8R	1
I	54.383	6R	4
	46.941	10	2
I	34.151	5R	4
	19.48	10	2
	3 283.45	10R	3
	65.347	6R	1
	60.814	7R	2
	54.20	10R	2
	47.17	7R	2
	43.84	8R	2
I	3 159.66	6R	1
I	58.76	6R	3
I	49.30	6R	2
I	47.06	7R	3
I	39.94	7R	3
I	37.32	6R	3
I	3 086.77	6R	3
I	82.61	5R	3
I	72.34	5R	3
I	44.00	8R	4
I	2 989.59	6R	3
I	87.17	5R	3

Co.—(*Continued*)

	λ	A	S
	2 886.45	5	2
	15.55	4	1
	2 766.22	4	2
	45.10	4	3
	31.11	4	2
	2 675.99	4	4
	63.53	4	10
	48.65	4	10
	32.4		10
	2 574.36	3R	
	64.04	3	10
	59.40	3	10
	41.95	2	10
I	28.97	3R	2
	19.8	1	10
	11.1	2R	4
	06.4	3	10
	2 464.2	2	8
	47.7		10
	32.3	3R	5
	24.9	3R	
I	15.3	3R	2
I	11.6	3R	3
I	07.3	3R	2
	2 397.4	1	10
	88.9	2	10R
	78.6	2	10
	63.8	2	10
	07.9	2	6R
	2 286.2	2	6R
	76.6	3	1
	13.9	3	1
	2 196.6	5	
	65.6	3	2
	05	4	1
	2 011.5		7
	1 974.1		4
	69.4		5
	56.6		5
	55.2		4
	50		4
	40.3		6
	28		5
	1 882.2		4
	46		4
	1 790.4		4
	72.7		5
	1 631.6		3
	1 580		5
	74		5
	02		3
	1 128		3
	937		5
	342		1

Cp, *see* Lu

Cr (74, 75, 78, 90, 91, 108, 146, 154, 181, 192, 212, 213, 226)

λ	A	S
26 232	2	
25 902	1	
850	2	

Cr.—(*Continued*)

λ	A	S
25 816	1	
785	1	
709	1	
665	1	
584	2	
560	1	
490	1	
460	2	
18 717	2	
654	3	
584	3	
479	3	
15 861	3	
680	3	
13 462	2	
11 611	10	
483	4	
392	5	
337	4	
312	2	
158	9	
016	8	
10 906	6	
820	4	
673	3	
486	4	
082	2	
9 948	2	
9 734.5	10	
9 670.5	5	
9 574.2	10	
9 447.0	10	
9 294.1	8	
90.4	10	
9 142.6	1	
41.1	1	
40.4	1	
9 035.9	3	
I 21.8	4	
I 17.08	5	
I 09.97	10	
8 976.8	3	
47.2	2	
8 548.8	2	
8 455.2	2	
50.3	2	
8 348.3	2	
8 235.9	2	
8 163.2	3	
7 942.0	2	
08.3	2	
7 722.9	2	
I 7 462.4	10	
I 00.3	10	
I 7 355.97	10	
I 6 979.81	7	
78.50	10	
I 25.23	9	
I 24.15	10	
6 883.04	9	
I 82.41	9	
I 81.65	9	
6 715.42	3	

Cr.—(*Continued*)

λ	A	S
6 669.26	4	
61.12	5	2
6 537.95	3	
01.23	3	
I 6 362.87	5	3
I 30.11	6	3
6 261.27	3	1
6 102.71	3	1
5 884.44	3	2
5 791.02	10	8
87.98	9	6
85.02	8	3
83.93	9	3
83.13	8	3
81.81	7	1
12.77	4	2
5 698.33	5	2
94.73	5	2
64.03	4	2
I 5 409.80	10	8
I 5 348.31	10	5
I 45.80	10	6
I 28.35	10	8
I 5 298.28	6	10
I 96.69	5	6
I 75.16	4	5
I 65.73	5R	3
I 64.15	6R	5
I 47.56	5R	3
I 08.429	10R	10
I 06.039	10R	10
I 04.54	9R	10
5 166.24	3	4
5 013.31	3	2
4 954.80	4	2
22.26	4	3
4 887.01	3	3
70.80	3	3
29.36	5	4
01.04	5	2
4 789.35	5	3
56.13	6	8
37.34	5	3
18.45	7	6
08.04	7	3
I 4 652.165	6R	5
I 46.172	7R	10
I 26.187	6R	5
I 16.132	6R	6
I 00.75	6R	4
I 4 591.41	6	2
I 80.06	7	3
I 45.96	5R	6
40.71	4	6
11.92	4	6
I 4 496.860	6R	10
65.35	4	4
58.53	4	3
I 4 384.98	6R	7
I 71.28	6R	9
I 59.63	6R	8
I 51.770	7R	9
I 51.05	5R	4

Cr.—(*Continued*)

	λ	A	S
I	4 344.510	7R	8
I	39.72	5R	4
I	39.45	6R	5
I	37.57	6R	9
I	4 289.725	10R	10
I	74.802	10R	10
I	54.340	10R	10
	4 179.26	4	3
	63.63	4	4
	09.58	4	1
	4 058.79	4	3
	26.17	4	2
	01.45	4	2
	3 991.13	6R	4
	83.92	7R	5
	76.68	7R	8
	69.75	7R	8
	63.70	7R	8
I	41.50	5R	3
I	28.65	6R	3
I	21.03	5R	3
I	19.17	7R	5
I	08.76	6R	3
I	3 894.05	4R	3
I	85.22	5R	3
	04.80	5	3
	3 749.00	4R	3
	43.88	4R	3
	43.56	4R	3
	3 639.81	6R	5
	36.59	5R	3
I	05.330	10R	10
I	3 593.484	10R	10R
I	78.687	10R	10R
	50.64	4	2
	3 433.60	5R	2
	22.74	3	10
	21.21	3	9
	08.76	3	10
	03.32	2	10
	3 382.68	2	10
	68.05	4	10
	60.32	3	10
	58.50	3	10
	46.73	4R	1
II	42.58	3	10
II	39.80	3	10
	07.05	1	8
	3 217.40	3	8
	09.18	2	10
	3 197.08	3	10
	80.73	3	10
II	32.053	4	10
II	24.974	4	10
II	20.37	4	10
II	18.65	3	10
	3 053.883	6R	2
	50.14	2	10
	40.852	5R	10
	37.049	5R	1
	34.197	5R	1
	21.57	6R	2
	18.502	5R	1
	17.58	6R	2

Cr.—(*Continued*)

	λ	A	S
	3 014.92	6R	1
	14.77	5R	1
	05.067	5R	1
	2 998.796	4R	1
	96.583	4R	1
	95.111	4R	1
	89.19	2	10
	86.470	6R	2
	85.32	2	10
	79.74	2	10
	71.90	2	10
	67.64	4R	1
	10.91	4R	1
	2 893.26	3R	1
	79.28	3R	1
II	62.58	3	10
II	55.68	4	10
II	49.83	4	10
II	43.25	5R	10R
II	35.64	5R	10
	30.48	2	10
	22.38	2	10
	12.01	2	10
	00.77	1	10
	2 792.16	1	10
	80.71	7R	
	69.91	6R	1
II	66.54	4R	10
II	62.60	3	10
	57.11	4R	2
	52.87	3R	1
II	51.87	3	10
II	50.73	3	10
II	43.63	3	8
	31.90	5R	1
	2 691.05	4	10
	78.79	4	10
	77.17	5R	10
	2 591.86	4R	1
	38.3		5
	2 408.67	2	1
	2 324.9		4
	2 226.5	2	2
	2 150.7	3	1
	33.5	3	1
	2 039.3	3	
	34.4	2	
	1 816.4		10
	1 018.7		3
	04.4		3
	925.5		2
	885.2		10
	840		3
	681.3		5
	67.1		5
	48.7		5
	37.8		6
	29.9		6
	19.9		6
	575.3		5
	469.8		4
	64.0		4
	56.8		4
	438.3		4

Cr.—(*Continued*)

λ	A	S
202.6		1

Cs (56, 61, 78, 90, 91, 174, 181, 182, 205, 223, 264)

	λ	A	S
	74 250	1	
I	71 930	1	
	71 110	1	
	69 310	2	
I	68 070	2	
I	42 202	4	
I	39 180	1	
I	36 128	2	
I	34 893	7	
I	30 963	4	
I	103	6	
I	29 317	8	
I	14 695	10	
I	13 605		
I	589	8	
I	10 124	10	
I	026	10	
I	9 209	6	
I	9 172.2	4	
I	8 944	6R	
I	8 761.3	4	
I	8 521.2	10R	
I	8 079.8	10r	
I	79.1		
	16.9	5r	
I	16.2		
I	7 944.0	8	
I	7 609.0	8	
I	7 280.0	5r	1
I	28.6	5r	1
I	6 983.4	6	1
I	73.3	10R	3
II	55.5		4
I	6 723.3	10R	3
I	6 587.1	5r	
I	86.5	10	1
	62.8		5
	6 354.5	4	1
	6 217.5	3	1
	13.0	8	2
II	6 128.6		4
	6 010.4	4	2
	5 925.7		5
II	5 831.2		5
II	5 563.0		4
II	5 419.7		5
	02.8		4
II	5 371.0		6
	5 274.0		4
II	49.4		6
II	27.0		8
II	5 096.6		4
II	43.8		6
II	4 972.6		5
II	52.8		6

Cs.—(*Continued*)

	λ	A	S
	4 870.0		6
II	30.2		6
	4 763.6		5
II	4 646.5		5
	23.1		4
	16.1		4
II	03.8	10	10
I	4 593.18	10R	3
I	55.5	10R	4
II	38.9		6
II	26.7		7
	01.5		7
II	4 435.7		4
	05.3		7
II	4 384.4		5
II	73.0		6
	00.6		6
II	4 288.4		7
II	77.1		9
	64.68		10
	32.19		6
	13.3		6
	4 158.6		4
II	4 068.8		6
	68.0		6
	39.8		9
	06.5		6
	3 974.2		6
II	65.2		6
II	25.6		6
II	3 897.0		7
	88.4	2	2
	76.2	1	
II	05.1		6
II	3 785.4		5
	3 699.5		5
	61.4		6
	08.3		5
	3 597.4		6
	59.8		5
	3 411.3		9
	3 350		8
	41		8
	16		8
	00		8
	3 268.3		10
	11		6
	3 152.7		6
	49.6		8
	3 067		10
	2 977		6
	63		8
	38		8
	31.1		10
	2 894		8
	87		10
	59		10
	45		10
	38		8
	11		6
	2 776		10
	07		10
	00		8

Cs.—(*Continued*)

λ	A	S
2 631		10
00		8
2 597		10
73		8
44		10
26		10
2 495		8
2 274.5		10
68.3		10
21.3		10
06.3		10
2 180.2		9
47.5		10
42.2		10
32.4		10
02.4		10
2 089.2		8
80.6		8
35.7		8
1 935.2		8
1 889.2		6
84.0		6

Ct, *see* Lu

Cu (3, 14, 59, 62, 74, 78, 90, 91, 111, 113, 170, 174, 181, 214, 223)

	λ	A	S
I	18 229	5	
I	194	7	
I	16 653	4	
I	008	5	
I	8 092.77	10	
I	7 933.23	10	
	7 570.1	5	
	6 905.9	6	
	6 741.4	6	
	6 672.23	5	
	6 485.16	5	
	74.20	5	
	6 325.4	4	
	6 268.3	6	
I	5 782.15	6	6
I	00.24	5	4
	5 554.94	2	1
	35.8	1	1
	5 292.54	4	4
I	20.06	6	5
I	18.203	10	10
I	5 153.26	8	8
I	05.545	7	6
	5 016.63	2	2
	4 704.60	4	2
	4 674.78	5	3
	51.17	8	7r
	4 587.00	10	10
I	30.84	8r	2
	09.39	6	3r
I	4 480.38	7	2
	4 378.2	8	8
	4 275.13	8	8
	48.97	6	4

Cu.—(*Continued*)

	λ	A	S
	4 177.7	6	2
I	4 063.4	6	1
I	62.7	10	7
I	22.70	10	8
I	3 861.75	3	1
	3 771.9	3	1
	41.25	3	1
	00.54	3	1
	3 621.23	6	2
	02.04	8	2
I	3 599.137	8	2
	33.74	7	1
	30.384	7	2
	27.49	5	1
	20.00	4	1
I	12.11	6	3
	3 483.75	6	3
I	57.850	4	1
	54.72	6	3
	50.33	7	6
	02.23	4	1
	3 381.428	3	1
	65.36	6	2
	37.850	8	3
	17.20	5	2
	07.950	9	7
	3 293.92	4R	2R
	90.546	10	6
	79.80	5	3
I	73.965	10R	10R
I	47.549	10R	10R
	43.15	6	4
	31.17	4	2
	08.20	6	2
I	3 194.10	8	3
	46.82	6	2
	42.43	7	2
	40.33	6	2
	28.67	6	2
	26.10	7	3
	16.33	7	2
	08.60	8	5
	3 099.92	6	3
	94.00	6	2
	73.82	5	2
I	63.42	7	3
	36.10	8	2
	10.843	7	1
	2 997.37	6	4
	61.183	9	6
	2 882.95	6	3
	24.38	10	5
I	2 766.39	10	4
	13.6	1	5
	01.1	1	5
I	2 618.39	10R	3
	2 529.43	1	5
	06.4	1	6
I	2 492.15	5R	2
	73.46	1	4
I	41.62	5	2
	00.10	2	5
I	2 392.64	7	1

Cu.—(*Continued*)

	λ	A	S
I	2 369.88	5	8
	56.63	2	4
	2 294.34	3	5
	93.85	6R	3
	76.24	1	4
I	63.1	3R	2
	46.98	3	6R
	42.60	2	6
	30.08	4R	2
I	27.75	4R	2
I	14.57	4R	2
	2 199.62	4Rd	2
	49	1	3
	1 999.6	5	2
	79.2	4	1
	1 840		8
	1 783		3
	69		4
	50		6
I	41		6
	22		6
	02		5
	1 687		6
	79		6
	72		6
	70		6
	52		6
	42		8
	1 594		5
	788.3		6
	77.3		5
	452.8		7
	358.0		5
	29.2		5
	24.5		6
	155.7		0

Dy (70, 90, 91)

λ	A	S
6 899.40	4	
35.51	6	
6 747.96	3	
6 667.93	6	
6 579.42	6	
6 486.62	5	
21.95	6	
6 386.89	5	
43.32	5	
6 259.12	10	
6 168.47	6	
6 088.27	6	
10.85	5	
5 974.52	5	
15.18	3	
5 868.18	3	
05.55	3	
5 740.23	3	
02.91	4	
5 685.57	4	
51.99	6	
00.68	5	
5 547.27	5	
15.40	5	1
5 423.30	5	

Dy.—(*Continued*)

λ	A	S
5 389.58	6	
80.68	6	
01.59	5	
5 260.58	5	
5 197.66	8	
69.64	6	
39.58	8	1
20.01	5	
5 032.98	6	
03.86	5	
4 957.41	10	2
23.14	6	1
4 890.12	5	1
32.43	5	1
25.00	5	1
4 775.81	6	1
45.79	6	2
31.84	10	3
4 698.72	4	2
12.27	8	4
4 589.35	10	5
77.81	6	3
03.25	5	2
4 449.72	8	4
09.40	8	3
4 375.33	5	2
58.50	5	2
08.66	5	4
4 295.02	6	5
56.33	8	3
25.14	6	3
21.12	8	3
15.13	6	3
11.74	10	5
4 194.85	8	4
86.80	8	4
83.68	6	3
67.99	10	4
46.06	6	2
11.35	8	4
03.34	8	8
4 077.98	10	10
46.00	10	4
00.50	8	10
3 996.72	5	4
78.57	6	10
68.42	10	10
44.69	10	10
3 898.54	6	10
36.49	6	4
06.25	6	10
3 786.20	6	5
57.37	4	3
24.42	5	5
3 698.17	4	10
94.75	6	10
76.56	3	10
45.40	8	10
00.34	6	10
3 576.89	6	3
63.12	6	4
50.21	8	10
46.83	6	4

Dy.—(*Continued*)

λ	A	S
3 536.04	5	5
31.70	10	10
24.03	5	10
3 494.47	8	5
84.66	6	3
54.36	6	10
13.77	6	3
07.77	8	3
3 393.58	6	3
85.03	6	3
53.57	5	2
19.87	6	3
08.87	6	3
3 282.78	5	3
69.12	5	1
35.87	5	3
16.60	5	3
3 162.79	4	3
41.09	4	2
3 043.46	4	1
16.98	3	1
2 985.92	3	1
48.30	3	1
06.39	3	1
2 877.90	3	1
16.38	3	2
2 772.59	3	
2 634.80	3	1
00.17	3	
2 560.19	3	
2 422.75	3	

Em, *see* Rn

Er (65, 66, 90, 91)

λ	A	S
7 680.00	3	
7 469.46	5	
7 316.29	3	
7 135.69	3	
7 001.44	3	
6 951.87	3	
6 897.53	3	
48.11	4	
6 759.88	4	
21.93	4	
6 616.75	4	
01.11	6	
6 583.47	5	
6 441.33	5	
6 388.19	6	
26.13	5	
08.79	8	
6 299.43	5	
21.01	6	1
6 076.46	5	
06.80	5	
5 902.10	5	
5 826.78	6	1
5 762.80	5	1
57.62	5	1
39.17	5	1
10.88	4	1

Er.—(*Continued*)

λ	A	S
5 665.45	4	2
26.52	4	1
01.19	4	1
5 593.40	4	1
5 485.93	5	2
56.58	5	1
54.25	5	1
22.79	5	1
14.63	6	1
5 395.86	6	2
44.49	5	1
02.31	5	1
5 279.31	5	
55.93	6	2
18.22	5	2
5 188.91	5	2
33.83	5	2
27.41	5	2
5 042.06	5	2
28.90	5	1
07.24	5	1
4 951.73	8	3
00.09	5	4
4 872.09	5	3
61.60	5	1
48.83	6	2
31.14	8	3
20.33	6	4
4 795.50	8	3
62.65	6	3
51.55	6	2
31.61	6	3
24.54	6	3
4 679.07	6	5
75.61	5	10
30.91	6	4
06.62	5	3
4 563.28	6	3
52.12	6	4
22.67	6	
00.75	8	6
4 473.51	5	4
19.62	8	10
4 374.95	10	6
19.95	5	3
4 276.50	6	3
30.19	6	3
4 194.81	10R	2
51.11	6	4
23.10	6	
4 087.66	10	1
48.34	5	3
07.96	10	4
3 987.64	5	1
69.46	5	2
38.65	8	4
06.34	10	10
3 896.26	6	6
92.72	6	2
30.54	6	6
3 797.08	6	3
87.88	6	3
66.26	10	3
29.56	5	5

Er.—(*Continued*)

λ	A	S
3 692.65		10
38.68	6	1
3 599.84	5	8
3 499.12	10	10
64.50	5	2
01.84	4	4
3 372.77	10	10
68.07	6	4
12.42	6	5
3 267.11	5	4
30.95	5	
3 154.28	4	3
3 070.77	4	2
25.91	4	2
2 964.52	4	3
10.36	5	4

Eu (69, 90, 91)

λ	A	S
7 217.55	8	
7 194.80	8	
7 077.14	8	
6 864.57	10	
02.78	10	
6 645.20	10	10
6 501.57	7	
6 437.63	10	5
6 350.02	10	1
03.42	10	3
6 262.26	10	2
6 188.10	10	2
73.03	10	3
6 083.89	9	1
5 967.09	10	1
5 831.98	10	3
5 577.12	9	1
70.31	10	1
47.44	10	1
5 452.95	9	2
51.52	9	2
02.77	10	2
5 357.61	9	1
5 223.48	5	1
5 133.52	5	1
5 022.91	6	1
4 911.40	8	2
4 661.90	10	10
27.26	10	10
4 594.07	10	10
22.56	10	10
4 435.54	10	10
4 205.01	10	10
02.01	10	
4 129.72	10	10
3 971.95	10	10
30.51	10	10
07.10	10	10
3 819.64	10R	10
3 724.97	10	10
3 688.42	10	10
3 334.32	5	2
3 111.43	5	1
2 906.68	5	5
2 727.77	4	6

F (26, 55.1, 103.1, 161, 217, 263)

λ	G	S
7 800.6	4	1
7 754.9	5	2
7 573.5	2	2
52.2	2	2
7 482.95	1	2
26	3	6
I 7 398.8	6	10
32.1	5	10
11.2	4	7
7 202.4	3	
I 7 037.56	9	
I 6 909.88	7	
I 02.49	9	
I 6 870.25	7	
I 56.05	10	
I 34.29	8	
I 6 774.00	6	
62.9	2	
6 569.72	2	
I 6 413.65	5	
I 6 348.50	6	
I 6 239.66	6	
4 446.8	10	
4 299.1	8	
46.3	10	
4 103.4	10	
4 025.1	10	
3 898.8	5	
51.7	5	
50.0	5	
47.1	5	
3 602.7	5	
01	5	
3 598.9	5	
05.8	10	
03.3	9	
01.9	8	
3 475.2	5	
73.5	5	
16.4	4	
3 262.7	3	
40.8	3	
01.1	3	
3 164.1	4	
51.7	3	
I 958.49	5	
I 55.53	6	
I 54.78	7	
I 51.81	5	
IV 679.19	5	
IV 77.17	5	
IV 76.06	4	
III 58.34	8	
III 56.86	6	
III 56.10	7	
II 08.06	8	
II 07.48	7	
II 06.95	4	
II 06.81	9	
II 06.27	7	
II 05.67	8	
IV 572.65	4	
II 46.84	4	

F.—(*Continued*)

	λ	G	S
III	467.70	7	
III	30.15	4	
	20.1	1	
	378.6	1	

Fe (40, 43, 109, 177, 178, 179, 193, 194, 197, 212, 215, 225, 245, 246, 260, 275)

λ	A	S
26 229	2	
25 987	3	
16 317	2	
166	2	
15 821	3	
815	3	
771	4	
625	3	
396	3	
296	4	
213	4	
054	2	
14 828	2	
711	2	
558	4	
513	8	
402	10	
288	4	
237	4	
13 899	5	
564	5	
12 034	3	
11 975	8	
884	5	
641	3	
10 144	3	
063	2	
9 738.7	2	
I 9 350.5	1	
9 258.5	3	
10.0	2	
9 118.9	4	
00.5	2	
9 089.4	4	
88.2	4	
79.6	4	
8 999.5	4	
8 866.9	3	
38.4	2	
I 24.254	6	
I 8 688.640	7	
I 61.92	6	
I 8 468.42	7	
I 8 387.786	8	
I 31.95	6	
I 27.06	8	
8 220.42	7	
8 085.21	5	
I 46.086	5	
I 7 998.98	6	
45.887	7	
I 37.18	9	
7 832.24	6	
7 780.595	5	

Fe.—(*Continued*)

λ	A	S
7 748.285	4	
7 664.304	4	
7 586.07	7	
I 68.931	4	
31.18	4	
11.05	9	
I 7 495.10	8	
I 45.781	9	
I 11.19	8	
I 7 389.43	7	
86.40	4	
I 7 293.08	6	
I 88.78	4	
I 39.90	4	
I 07.42	10	
7 187.34	10	
I 64.48	9	
I 30.95	10	
I 7 090.414	6	
68.420	5	
6 978.860	7	
45.213	7	
16.710	4	
6 885.77	4	
55.182	6	
43.681	4	
41.36	5	
28.614	4	
6 750.16	4	
6 678.00	5	
63.45	4	
09.12	4	
6 592.92	5	1
69.23	5	
46.250	5	1
6 494.99	5	3
62.735	4	
I 30.855	5	1
21.36	4	1
11.67	5	1
08.04	4	
00.02	5	3
6 393.61	5	2
36.84	4	1
I 35.34	4	1
18.026	4	1
I 01.52	5	1
I 6 297.802	3	
I 65.142	4	1
52.565	4	2
46.34	4	1
30.732	5	3
I 13.439	3	1
6 191.566	5	3
I 73.344	3	1
57.733	2	1
37.700	4	3
36.623	4	3
6 065.491	4	2
27.058	3	1
24.06	4	2
5 952.745	4	1
34.68	4	1

Fe.—(*Continued*)

λ	A	S
5 930.17	5	
14.16	6	1
5 883.842	4	
62.35	4	
5 763.01	4	1
31.772	3	
17.85	3	
I 09.39	3	1
01.553	3	
I 5 658.83	4	1
I 24.55	5	1
I 15.66	6	4
5 598.30	3	1
I 86.769	6	4
I 76.10	4	1
I 72.85	5	3
I 69.630	5	2
63.609	3	1
I 06.783	4	2
I 01.470	4	2
I 5 497.521	4	2
I 73.911	3	1
I 55.614	6	6
I 46.920	6	6
I 34.527	6	5
I 29.701	6	6
24.06	4	8
15.19	4	6
I 05.780	6	6
I 5 397.133	6	6
83.37	5	6
I 71.495	7	6
41.027	5	2
28.536	4	2
I 28.044	7	6
I 24.190	6	5
I 02.31	5	2
I 5 283.63	7	2
I 81.80	5	2
70.360	8	4
I 69.540	10	8
I 66.566	8	3
42.496	3	1
I 32.95	8	5
27.191	8	4
I 16.28	5	1
I 02.340	5	1
I 5 198.715	4	1
I 94.948	5	1
I 92.35	8	2
I 91.46	7	2
I 71.601	7	2
II 69.03	2	5
67.492	8	4
66.288	3	1
I 51.916	3	1
I 50.844	4	1
I 39.48	8	3
I 39.27	6	2
33.68	5	2
I 27.364	3	1
I 23.725	4	1
10.415	4	1

Fe.—(*Continued*)

λ	A	S
I 5 107.646	4	1
I 5 098.706	7	1
I 83.344	4	1
I 79.743	3	1
I 79.228	3	1
I 51.640	4	1
I 49.826	5	2
I 41.760	3	1
41.077	3	1
I 12.072	4	2
I 06.131	5	2
01.87	5	2
I 4 994.135	3	1
83.858	4	1
66.10	5	1
I 57.61	10	8
I 57.31	7	3
I 38.825	5	1
I 20.515	10	8
I 19.00	8	4
I 03.32	5	2
I 4 891.50	9	5
I 90.77	7	4
I 78.220	5	2
I 72.149	6	3
I 71.330	8	4
I 59.75	2	2
4 789.655	3	2
86.812	3	1
41.533	3	1
36.78	5	3
I 33.597	3	1
10.288	3	1
I 07.28	5	2
4 691.416	4	2
78.855	5	2
67.461	4	2
I 54.503	4	
47.438	4	2
38.019	4	1
I 32.918	3	1
30.128	3	4
19.297	4	1
11.290	4	2
I 07.662	4	1
I 02.946	3	2
I 4 592.656	4	2
47.853	3	2
I 31.154	5	2
I 28.621	7	6
I 4 494.570	4	5
89.745	3	1
I 82.262	4	4
76.024	7	4
69.387	4	3
66.556	5	3
61.657	4	2
I 59.125	5	3
I 47.724	5	2
I 42.346	5	2
I 30.621	4	1
27.313	5	2
22.572	4	2

Fe.—(*Continued*)

	λ	A	S
I	4 415.128	8	10
I	08.420	4	1
I	04.754	8	10
I	4 383.549	10	10
	75.933	5	2
	69.777	3	2
	52.739	4	2
I	37.052	5	2
I	25.767	9	10
I	15.089	5	3
I	07.908	8	10
	4 299.24	7	4
I	94.130	6	4
	82.408	6	3
I	71.765	8	10
	60.484	10	10
I	50.792	8	6
	50.130	7	4
	47.438	5	2
	38.82	4	2
	35.95	8	4
	33.611	6	3
	27.439	7	4
	25.463	4	1
	22.224	5	2
	19.365	5	3
	16.188	4	1
	10.357	6	3
I	02.033	7	6
	4 199.099	6	5
	98.313	6	3
	91.44	6	3
	87.807	6	4
	87.048	6	4
	84.895	4	2
	81.760	6	4
	75.642	4	2
	56.804	4	2
	54.816	4	2
I	47.675	4	1
I	43.873	7	5
	43.420	5	3
	34.683	5	2
I	32.062	7	4
	27.615	4	1
	18.551	6	3
	14.453	4	1
	09.810	4	2
	07.494	5	2
	4 076.638	5	2
	74.792	3	1
I	71.744	7	8
	67.986	5	1
	67.277	3	1
	66.983	4	1
I	63.600	8R	10
	62.448	4	2
I	45.818	8R	10
	21.871	5	2
	14.536	4	2
	09.717	5	2
I	05.248	7	6

Fe.—(*Continued*)

	λ	A	S
	3 998.059	5	2
	97.397	6	3
	83.963	5	2
	77.745	5	2
	71.327	4	1
I	69.262	7	5
	67.425	4	2
I	66.068	5	2
	56.682	6	3
	56.461	4	2
	52.607	4	1
	51.168	4	2
	49.957	4	2
	48.780	4	2
	42.445	3	1
I	40.883	4	1
	35.817	4	1
I	30.302	7R	4
I	27.924	6	4
I	22.916	6R	4
I	20.261	6	4
	18.646	4	1
I	17.186	5	2
	07.938	3	1
I	06.484	5	3
	03.903	3	1
I	02.949	7	5
I	3 899.711	6	4
I	98.01	4	2
	97.895	4	2
I	95.660	5	3
	93.396	4	2
	91.932	4	1
I	88.519	7	4
I	87.053	6	3
I	86.286	7R	5
	78.66	4	
I	78.576	6R	5
I	78.022	6	4
	73.765	4	2
I	72.505	6	4
	67.221	3	2
I	65.527	6	4
I	59.913	7R	6
	59.215	5	2
I	56.373	6R	5
I	50.821	5	2
I	49.970	6	4
	43.261	5	2
I	41.052	6R	5
I	40.440	6R	4
	39.259	5	2
I	34.226	7R	6
	33.313	4	1
I	27.826	6R	8
I	25.885	8R	8
I	24.445	6R	5
	21.182	6	3
I	20.430	8R	10
I	15.843	7R	10
I	12.967	6	4
I	07.541	4	2

Fe.—(*Continued*)

	λ	A	S
	3 806.701	6	3
	05.346	6	3
I	3 799.550	6	5
I	98.513	6	4
	97.518	5	3
I	95.005	6	5
	90.095	4	2
	87.883	6R	4
	85.950	5	2
I	67.195	6R	5
	65.543	6	3
I	63.791	6R	6
	60.053	5	2
I	58.236	7R	8
I	53.615	5	2
I	49.488	8R	10
I	48.265	6R	4
I	45.902	6	4
I	45.564	7R	5
	43.470	4	6
	38.309	4	2
I	37.135	7R	6
I	34.868	9R	10
I	33.320	6R	3
	32.399	6	1
I	27.622	6R	5
	24.380	6	2
I	22.565	6R	4
I	19.938	8R	10
	16.449	6	
I	09.250	6	4
	07.922	5	4d
	07.825	3	
I	05.568	6R	4
	04.464	5	2
	01.086	6	2
	3 694.002	6	2
	89.459	6	2
I	87.459	6R	4
	86.000	5	2
	84.112	5	2
I	83.058	4	2
	82.24	6	3
I	79.916	5	3
	77.631	6	2
	76.314	4	1
	69.524	6	2
	59.520	5	1
	55.467	4	1
	51.741	6	3
	49.509	6	3
I	47.846	6R	6
	45.825	4	2
	40.392	6	3
	38.299	6	2
	37.862	4	1
	34.336	5	1
	32.041	6	2
I	31.465	6R	6
	31.098	5	1
	25.149	4	1
	23.188	5	2
	22.007	6	3

Fe.—(*Continued*)

	λ	A	S
	3 621.463	6	3
I	18.770	6R	6
	17.789	6	3
	12.079	4	1
	08.861	6R	6
	06.682	5	4
	05.461	5	3
	03.206	5	3
	3 589.454	3	1
I	89.107	4	1
I	86.988	6	3
	86.115	5	3
I	85.709	5	3
I	85.321	6	3
	84.960	5	2
	84.664	5	2
	82.203	4	2
	81.197	8R	10
	76.761	4	1
	71.998	7	2
	70.24	7	
I	70.102	7R	10
	68.979	4	1
I	65.382	6R	5
I	58.519	5	4
	56.881	6	2
	54.928	8	4
	53.744	5	2
	45.642	5	1
	42.080	6	3
	41.089	6	3
	40.129	4	1
	37.730	4	1
	36.558	6	3
	33.196	5	2
	33.006	4	1
	30.384	4	1
	27.796	4	1
	26.673	5	1
	26.468	4	1
	26.378	3	
I	26.167	5	2
I	26.02	4	2
	24.242	4	1
	24.076	4	1
I	21.265	5	3
I	13.821	5	3
	06.500	5	1
I	3 497.844	5	3
	97.111	4	2
I	90.576	6R	4
	89.673	4	1
	85.343	6	1
I	83.010	4	1
I	76.707	5	3
	75.653	4	
I	75.456	6R	3
	68.849	4	1
I	65.865	6R	3
	59.917	4	1
I	52.280	4	1
	51.919	6	1
	50.333	6	1

Fe.—(*Continued*)			Fe.—(*Continued*)			Fe.—(*Continued*)			Fe.—(*Continued*)		
λ	A	S	λ	A	S	λ	A	S	λ	A	S
3 447.282	6	1	II 3 227.757	4	5	I 3 031.643	5	2	2 838.120	6	1
45.153	4	2	25.791	8	3	31.219	4	2	32.435	6	1
I 43.881	6R	3	22.072	6	3	30.155	4	2	31.56	3	4
42.365	4	1	19.817	4		I 26.469	6	2	I 27.89	4	1
I 40.991	6R	4	19.58	5		I 25.848	5	2	I 25.69	4	1
I 40.612	7R	4	17.387	4	1	25.639	4	2	25.56	6	1
28.197	6	2	15.943	5	2	I 24.038	5	2	23.278	7	2
27.123	6	4	14.046	8	2	I 21.077	6R	3	I 13.289	9	2
26.640	6	1	II 13.32	4	2	I 20.645	6R	3	06.985	7	2
I 26.389	4d	1	12.000	4	2	I 20.498	5	2	04.524	7	1
24.289	6	2	11.696	4	1	I 18.989	5	2	2 797.777	4	1
22.663	4	2	10.836	5	1	I 17.633	5	2	91.79	3	1
18.511	5	2	10.245	4	1	11.486	4	1	89.81	3	1
17.845	6	2	05.400	7	1	I 09.576	5	2	88.107	6	2
13.136	7	3	00.479	6	1	08.145	5	2	87.94	4	
07.463	7d	4	I 3 199.527	6	1	I 07.287	4	1	83.69	3	5
04.354	6d	2	96.940	4	2	07.148	4	1	I 81.80	4	1
02.262	4	1	92.807	5	2	I 00.953	5	2	79.30	3	4
3 399.338	6	2	91.664	5	1	00.454	4	1	78.85	4	1
94.591	4	1	88.838	5	1	2 999.517	5	2	I 78.228	6	1
92.658	5	2	I 84.901	4	1	I 94.436	6R	3	I 74.73	4	2
92.309	4	2	81.53	4	1	90.396	4	1	73.23	4	1
83.985	5	1	I 80.765	4		I 87.296	5	1	I 72.112	6	1
83.698	4	1	80.227	8	2	II 84.834	4	6	72.08	4	
80.115	5	1	78.014	6	1	I 81.448	4	2	I 67.518	7	5
79.024	4	1	75.449	6	1	I 73.237	4	2	I 66.91	4	1
78.683	4	1	71.35	4	1	I 73.137	4	2	64.33	4	1
70.787	6	2	66.442	4	1	I 70.108	4	2	63.11	4	1
55.234	4	1	61.947	5	1	I 69.483	4	2	I 62.029	5	1
47.932	4	1	60.660	6	1	I 66.901	6R	3	61.81	4	
41.912	4	1	57.878	4	1	I 65.258	5	2	I• 61.785	5	2
37.670	4	1	57.042	4	1	59.997	4	2	59.816	4	1
28.870	4	1	51.347	6	1	I 57.370	5	2	57.32	4	1
23.741	4	1	43.985	6	1	I 53.943	4	2	I 56.332	5d	1
14.746	6	1	42.891	4	1	50.25	6	1	II 55.74	8	10
06.358	8	3	42.447	4	1	48.44	4	1	I 54.03	4	1
05.978	8	3	I 34.114	5	1	I 47.878	5	3	53.69	4	1
3 298.137	5	1	29.337	4		47.66	4	4	53.29	4	5
92.60	5	1	I 25.664	6	2	44.40	4	4	50.87	4	
92.03	5	1	20.436	4	1	I 41.345	8	3	I 50.15	6	2
90.993	4	1	19.496	4	1	37.81	6		II 49.324	7	10
86.761	8	3	I 16.636	5	1	I 36.904	7R	2	49.183	4	
84.593	4	1	I 00.671	4	3	I 29.006	7	1	II 46.987	7	8
82.90	4	1	I 00.309	4	2	II 26.58	7	3	II 46.486	7	10
80.265	5	1	I 3 099.97	4	4	18.029	5	2	44.53	5	1
71.008	6	2	I 99.901	4		I 12.160	8	2	I 44.07	8	1
68.25	4		I 91.582	4	2	2 899.420	4	1	II 43.199	6	8
65.623	6	2	I 83.747	4	3	95.04	4	1	I 42.41	6	1
65.053	3	1	I 75.725	5	3	94.51	4	1	I 42.258	4	1
64.521	4	1	68.180	4	1	87.81	4	1	II 39.551	9	10
57.599	4	1	I 67.253	5	3	77.303	5	1	I 37.31	6	1
54.368	4	2	67.123	4		I 74.177	7	1	II 36.971	4	4
51.24	5	1	I 59.092	5R	3	72.34	4	3	I 35.479	8	2
48.211	6	1	I 57.453	5	3	I 69.310	6	1	34.27	4	1
46.973	4	1	55.268	4		66.63	4	1	34.01	4	1
44.189	8	2	53.071	4	1	I 63.867	5	1	I 33.580	9	2
39.441	8	2	I 47.611	6	3	63.434	4	1	30.74	4	3
I 36.227	5	1	45.086	4		I 58.898	4		28.03	4	1
34.621	5	1	I 42.673	5	2	51.800	8	2	27.541	5	6
33.975	6		I 42.028	4	1	48.718	4	1	27.39	3	2
33.056	5	2	I 41.748	4	2	45.595	4d	2	26.24	3	1
28.262	4	1	40.434	4	2	43.97	7	2	26.06	4	1
27.816	4	5	I 37.393	5	3	43.63	5	1	24.96	4	

Fe.—(*Continued*)

	λ	A	S
	2 724.89	3	3
I	23.581	6	2
I	20.909	7	2
	19.43	4	2
	19.036	7	2
	18.45	4	1
	14.88	4	
II	14.417	6	5
	11.66	5	
	10.55	4	1
	08.58	4	1
	06.59	5	2
	04.00	3	4
	2 699.11	4	1
	96.29	5	
	96.00	4	
	94.54	4	
	92.61	3	4
	89.84	4	1
	89.22	5	2
	84.76	3	4
	81.59	4	
	79.064	6	2
	66.82	4	
	66.64	3	4
	64.67	3	4
	56.15	3	1
	51.72	3	1
	41.65	3	1
	35.82	4	1
	32.25	4	1
	31.33	6	3
	31.05	6	4
	30.08	3	2
I	29.60	5	3
	28.300	6	8
II	25.68	8	4
	25.50	4	3
	23.54	4	1
	21.674	6	4
	20.70	3	2
	20.42	3	2
	19.08	3	2
	18.03	4	1
	17.624	6	6
	13.84	8	8
II	11.88	8	10
	07.098	7	10
	06.83	5	
	2 599.57	3	
II	99.40	6	10
	98.377	7	8
	92.80	4	4
II	91.55	4	4
	88.006	5	3
	87.96	3	
II	85.884	7	10
	84.542	4	1
II	82.591	4	4
	82.31	4	
	77.94	4	3
	76.87	4	3
	76.70	4	

Fe.—(*Continued*)

	λ	A	S
	2 575.76	4	1
	74.37	3	4
	70.86	3	3
	70.54	3	1
	66.921	4	3
	63.482	5	4
II	62.541	5	5
I	49.62	6	
	44.72	4	
	43.926	5	1
	42.11	5	1
I	40.977	6	
	37.18	6	
I	35.612	6	
	33.7		5
I	29.84	6	
I	29.139	6	1
I	27.44	4	2
	25.4		4
I	24.29	6	1
	23.66	4	1
I	22.86	4	3
I	18.11	6	1
	17.66	4	1
	12.37	4	
	11.8		5
I	10.839	6	1
	07.90	4	1
	2 496.54	5	1
	93.3		8
I	91.16	4	
I	90.66	4	
I	89.76	6	
I	88.15	4	2
	87.37	4	1
	86.07	4	1
	86.69	4	1
	86.38	4	3
I	84.19	6	
	83.54	4	
	83.28	5R	1
I	79.78	4	1
	74.82	5	2
	73.16	4	
I	72.91	4	1
I	72.87	5	
	72.35	5	
	68.88	5	1
	65.16	5	
I	62.65	6	1
I	62.19	6	1
	57.60	6	1
	53.48	4	1
I	47.72	4	2
	44.5		4
	43.87	4	1
	42.57	4	1
	39.75	4	1
	13.31	6	3
	11.07	6	3
II	10.53	6	5
	06.66	6	4
II	04.89	6	6

Fe.—(*Continued*)

	λ	A	S
	2 404.43	4	2
	2 399.24	6	5
II	95.63	8	4
	95.42	4	3
	89.98	4	
	88.63	6	3
	83.25	4	2
II	82.04	8	10
	80.76	4	3
	79.28	4	3
II	75.19	4	
II	73.73	6	4
	73.62	4	
	70.5	6	
II	68.59	7	
	66.59	5	
	64.83	8	
	62.1	8	
II	60.3	5	
	59.11	6	
	54.9	6	
	51.2	4	
	48.3	5	
	48.12	5	
	44.3	4	
	43.50	7	
	38.01	6	
	32.80	6	
	27.39	6	
	13.1	5	
	10.01	5	
	00.1	5	
I	2 299.2	5	
I	98.2	7	
I	97.8	6	
	92.5	5	
	91.1	6	
	90.6	5	
	89.0	6	
	87.6	5	
	87.3	5	
	80.2	6	
	79.9	6	
I	76.0	5	
	74.1	5	
	72.8	5	
	67.6	5	
	67.1	5	
	66.9	5	
	65.2	5	
	60.8	6	
	55.8	7	
	53.2	6	
	51.9	6	
	49.2	7	
	48.9	6	
	45.6	6	
	40.6	5	
	31.2	7	
	29.1	6	
	21.3	4	
	13.6	4	
	00.7	5	

Fe.—(*Continued*)

λ	A	S
2 199.5	5	
96.0	5	
91.8	5	
78.1	5	
71.3	5	
66.8	6	
65.8	5	
59.9	5	
51.7	5	
44.4	5	
39.7	5	
06.4	4	
2 093.7	4	
84.2	4	
63.7	3	
40.6	3	
20.6	3	
00.3	3	
1 953.6		2
14.2		3
13.3		4
1 895.6		4
69.7		4
43.9		2
1 788.3		5
87.0		5
24.0		2
18.3		2
02.0		3
1 630.9		2
1 597.7		2
38.3		2
32.3		2
25.5		2
1 430.6		2
09.4		2
1 387.8		2
73.9		2
1 272.2		2
60.8		2
54.1		2
28.9		2
1 186.4		2
43.4		2
1 062.1		2
31.8		4
17.6		6
06.0		2
983.8		3
29.2		3
863.2		3
59.9		4
669.9		4
66.9		4
09.1?		9
02.4		4
552.1		7
417.5		4
392.9		7
81.1		4
65.8		5
294.3		2

Ga (46, 78, 90, 91, 149, 269, 271, 282)

	λ	A	S
I	6 413.74	8R	
I	6 396.8	10	5
	4 864.9		5
	4 172.05	10R	10R
	4 033.01	10R	10R
	3 806.8		5
	3 575.3		7u
	3 004.1		6
I	2 944.20	5R	1
I	43.65	10R	2
I	2 874.24	10R	2
	2 780.2		9
I	19.66	3	8
I	2 659.87	2	7
I	2 500.18	2	7
I	2 450.07	1	4
	18.70	1	4
	2 371.30	1	3
	38	1R	
	2 294	1R	2
	1 845.0		8
	13.9		9
	02.3		7
	1 799.2		7
	1 625.3		7
	1 586.3		8
	34.5		10
	1 495.4		10
	83.9		6
	14.4		10
	1 338.1		7
	03.5		10
	1 299.5		9
	95.9		10
	93.5		6
	85.3		7
	79.2		7
	67.1		7
	64.6		6
	58.8		9
	28.0		7
	1 195.0		6
	92.9		6
	70.4		9
	63.5		6
	56.1		7
	36.9		5
	35.9		5
	33.6		6
	26.1		5
	20.6		5
	02.7		7
	1 050.2		6
	989.5		6
	938.5		6
	909.3		5
	874.4		6
	860.4		5
	839.9		5
	828.8		5
	800.4		5
	645		2

Ga.—(*Continued*)

λ	A	S
511		3
509		3
425		4
124		0

Gd (68, 90, 91, 144)

λ	A	S
7 846.36	3	
7 733.50	4	
7 563.02	6	
7 464.37	4	
7 394.91	4	
24.91	5	
13.28	4	
01.24	4	
7 262.7	5	
52.72	5	
01.43	4	
7 189.64	5	
72.30	6	
68.3	10	
47.37	5	
22.58	5	
18.90	4	
7 068.07	4	
54.61	4	
50.97	4	
37.24	5	
06.13	5	
6 996.77	10	
91.89	6	
85.86	7	
57.71	4	
16.58	7	
6 887.65	5	
57.14	5	
46.61	8	
28.30	6	
6 752.67	5	
6 634.4	5	
6 305.16	5	1
6 114.07	6	1
5 913.56	4	1
5 754.20	5	
51.85	5	
33.86	6	1
01.35	5	
5 696.20	8	
43.24	5	
17.91	5	
5 535.16	7	
5 393.64	8	
70.69	5	
53.21	5	1
50.36	5	1
42.98	5	1
5 155.84	6	1
03.46	5	1
5 092.24	5	2
15.03	6	2
4 821.69	6	2
01.03	5	3
4 786.80	5	1

Gd.—(*Continued*)

λ	A	S
4 767.23	6	2
58.67	6	2
43.64	6	3
32.58	5	4
28.46	6	4
4 683.34	5	2
01.03	5	5
4 597.90	4	5
96.97	4	4
82.50	5	3
40.01	4	10
19.62	5	3
06.24	6	2
4 476.13	5	3
38.23	5	8
36.18	6	10
22.44	6	3
21.27	3	8
19.04	5	8
06.67	4	10
01.86	5	3
4 387.63	5	3
47.25	5	3
46.45	8	2
42.18	10	10
41.25	7	5
27.11	8	4
25.66	9	5
16.05	5	3
4 280.54	7	5
62.09	9	10
51.75	8	10
38.77	5	4
25.87	7	3
25.10	5	3
17.15	5	5
14.97	6	5
12.00	7	5
4 197.68	5	5
84.28	9	10
37.10	6	8
32.29	5	5
30.39	10	10
4 098.91	5	4
98.64	8	6
85.59	8	8
78.73	5	3
78.46	5	4
73.80	8	8
70.36	9	5
63.46	10	5
49.90	8	6
49.44	6	4
37.89	7	5
37.34	9	6
3 994.20	5	3
59.51	7	6
57.69	5	5
34.81	6	3
16.57	9	8
3 894.72	6	4
52.50	10	8
51.00	7	5

Gd.—(*Continued*)

λ	A	S
3 850.69	7	4
13.99	9	6
3 796.43	9	10
70.70	4	6
68.40	10	10
58.29	5	4
43.41	7	10
30.87	5	5
19.48	9	10
16.38	5	4
12.71	6	10
3 697.74	5	5
87.76	5	5
71.24	10	8
64.64	7	10
56.15	7	8
54.64	7	8
46.19	10	10
13.42	5	4
3 592.69	5	8
84.96	8	10
49.37	7	10
45.78	9	10
3 494.41	5	5
81.83	5	5
81.33	6	8
50.38	5	6
40.06	7	6
39.21	6	5
22.46	8	10
18.72	7	4
16.93	5	4
3 362.25	6	10
58.60	7	8
50.48	7	10
3 145.00	5	4
00.51	8	8
3 082.00	10	6
34.06	7	6
32.85	7	8
27.60	6	6
10.15	5	6
2 999.06	5	4
55.50		10
04.73		10
2 717.30		8
2 679.41		8
55.59		6
28.12		10
2 564.51		6

Ge (46, 90, 91, 123.1, 161.1, 228, 231)

λ	A	S	G
6 484.2			5
6 021.04			10
5 893.42			10
5 701.88			4
5 691.94			6
21.41			6
06.98			1
5 564.72			5
5 229.37		6	
5 178.57			7

Ge.—(*Continued*)

	λ	A	S	G
5	134.71			10
	31.69		7	
4	854.74	6		
	14.70		9	8
4	743.8		2	
I 4	685.84	5	10	
4	291.56		3u	
	60.81		10	
I	26.73	7	10	
4	179.0		10	
I 3	269.50	10	10	
I 3	124.83	10	5	
3	067.04	7	1	
I	39.09	10R	10R	
2	845.4		4	
	29.01	3	2	
2	793.94	3	2	
I	54.59	10	10R	
	40.44	8	7	
	09.68	10	10R	
I 2	691.35	10	10	
I	51.58	10	10R	
I	51.18	10	10R	
	44.18	2	2	
I 2	592.55	10	10R	
I	89.20	3	5	
	56.29	1		
I	33.24	3	6	
I 2	497.97	3	7	
	17.28	3	10	
2	379.15	1	3	
	27.93	1	3	
	14.22	1	3	
2	198.71		2R	
1	733		6	
1	500.6		6	
1	402.8		6	
1	393.8		8	
1	237.0		6	
	29.8		10	
1	189.0		10	
	83.4		8	
	73.7		6	
	60.8		8	
	59.5		8	
	38.0		8	
	16.8		6	
	05.0		6	
1	098.6		5	
	88.3		8	
	72.4		6	
	58.8		6	
	45.5		7	
	16.5		8	
	11.2		9	
	04.2		6	
	996.5		8	
	95.7		8	
	89.0		6	
	38.9		6	
	36.7		9	
	15.0		8	
	892.6		5	
	68.3		6	

Ge.—(*Continued*)

λ	A	S	G
847.9		5	
760.3		3	
547.0		1	

Gl, *see* **Be**

H (51, 89, 120, 165, 187.1, 202, 208, 218, 236, 278)

First spectrum (G)

74	000
40	500
26	300
18	751
12	817
10	900
9	500
6	562.85
	62.73
4	861.327
4	340.465
4	101.735
3	970.074
3	889.06
	35.40
3	797.91
	70.06
	50.15
	34.37
	21.95
	11.98
	03.86
3	697.15
	91.55
	86.83
	82.82
	79.35
	76.34
	73.7
	71.34
	69.42
	67.7
	66.1
	64.6
	63.4
	62.2
	61.2
	60.3
	58.0
	57.6
	56.6
1	215.68
1	086
	25.73
	992
	972.54

Second spectrum

λ	G
7 072	10
6 962.6	10
40.4	10
35.8	10
6 327.04	8

H.—Second spectrum.—(*Continued*)

λ	G
6 299.40	6
38.37	7
24.81	9
6 199.38	6
82.98	6
35.35	8
27.3	6
21.78	10
6 095.98	6
90.93	6
79.80	9
70.00	7
31.9	10
27.98	6
18.30	9
5 982.55	7
75.44	9
49.91	7
38.62	7
31.4	7
5 888.16	6
36.0	7
12.58	9
5 775.0	6
36.86	7
31.90	6
5 688.20	6
5 537.45	6
05.5	5
5 481.09	5
34.84	5
19.90	6
5 388.2	7
66.0	5
36.51	5
03.16	7
5 266.04	5
5 196.38	5
13.18	5
5 084.84	5
55.07	6
13.05	6
4 973.26	6
34.27	6
28.7	9
4 873.03	5
49.32	5
4 797.74	5
23.00	6
19.01	6
4 683.78	6
62.77	5
34.0	9
31.88	9
27.96	6
25.3	5
4 582.60	6
80.03	7
72.72	6
68.11	7
4 498.10	6
90.45	6
60.96	6

H.—Second spectrum.—(*Continued*)

λ	G
4 447.56	5
12.25	5
4 212.51	6
05.10	7
4 177.07	6
71.29	5
4 087.75	4
69.65	6
62.49	6
3 991.9	4
90.03	4

He (93, 185, 202, 203, 241)

λ	G
I 40 540	
I 20 581	20
I 10 830	5
I 829	1
I 7 281.35	3
I 7 065.19	5
I 6 678.149	6
I 5 875.620	10
I 4 921.928	4
I 4 713.143	3
I 4 471.479	6
I 4 387.93	3
I 4 143.76	2
I 20.81	3
I 4 026.19	5
I 3 964.73	4
I 3 888.65	10
I 19.60	4
I 3 613.64	3
I 3 447.59	2
I 3 203.17	8
I 3 187.74	8
I 2 945.10	6
I 2 829.06	4
I 2 763.80	2
I 33.24	7
I 2 511.22	5
I 2 385.39	5
I 06.12	2
I 2 252.81	2
II 1 640?	5
II 1 215?	
I 585?	10

Hf (112)

λ	A	S
7 131.8	6	
6 819.0	6	
6 789.4	6	
6 644.7	6	
5 902.9	6	3
5 719.2	6	4
5 552.1	6	4
50.6	6	4
5 463.3	6	3
5 373.9	6	3
54.7	6	2
11.5	6	4
5 298.0	6	3
5 181.9	6	3

Hf.—(*Continued*)

λ	A	S
5 040.8	6	6
37.3	6	1
18.1	6	4
4 975.2	6	5
4 800.5	6	6
4 620.8	6	5
4 598.9	6	6
4 417.9	4	6
4 356.3	5	6
50.5	4	6
36.7	5	6
4 232.4	4	6
4 093.2	6	6
44.4	8	3
3 918.1	6	6
3 719.3	6	6
01.1	5	6
3 682.2	6	6
44.3	6	6
16.9	5	6
3 569.0	5	6
61.6	6	6
52.7	5	6
05.2	6	6
3 479.2	6	6
10.2	5	6
3 399.8	6	6
52.0	6	6
32.7	6	6
18.0	5	6
12.9	6	6
3 255.3	5	6
53.7	6	6
3 194.2	6	6
76.9	6	6
72.9	5	6
62.6	5	6
45.3	5	6
34.8	6	6
09.1	6	6
01.4	6	6
3 080.8	6	6
72.9	6	5
67.4	6	5
31.2	5	6
16.8	6	5
12.9	6	6
2 975.9	5	6
68.9	6	5
29.6	6	5
19.6	6	6
16.5	6	5
2 898.3	6	5
66.4	6	6
61.7	6	6
61.0	5	6
22.7	6	6
20.2	6	6
2 773.4	6	6
38.7	5	6
06.7	6	5
05.6	6	6
2 683.4	5	6

Hf.—(*Continued*)

λ	A	S
2 647.3	6	6
41.4	6	6
38.7	6	6
22.8	6	6
2 571.7	5	6
51.4	5	6
16.9	6	6
13.0	6	5
12.7	6	5
2 469.2	4	6
60.5	6	6
47.2	5	6
17.7	5	6
10.1	5	6
2 351.2	5	6

Hg (14, 45, 82, 90, 91, 135, 164, 203, 204, 205, 206, 265, 273, 276, 283, 287)

λ	A	S
40 159	8	
I 39 425	10	
36 492	2	
I 23 253	1	
19 701	1d	
18 333	1	
I 17 110	2	
I 073	2	
I 16 921	2d	
15 295	5	
I 13 950	4	
I 673	8	
I 570	6	
I 11 888	1	
I 287	9	
I 10 140	10	
7 729.2	6	
I 7 082.0	4	
I 6 907.5	10	
I 6 234.35	8	
6 123.47	6	
I 6 072.63	5	
I 5 790.66	10	5
I 69.60	10	5
I 5 675.8	5	
I 5 460.73	10R	10R
4 960.3	5	
I 16.0	5	1
I 4 358.34	10	10R
I 47.50	6	1
I 39.23	6	1
I 4 077.8	7	5R
I 46.56	10	10R
3 983.99	6	8
I 06.4	6	
I 3 663.27	6	5
I 62.87	4	4
I 54.83	7	5
I 50.15	10	9R
I 3 341.48	6	5
I 3 131.84	7	4R
I 31.56	7	5R
I 25.6	8	8R
I 3 021.50	5	4

Hg.—(*Continued*)

λ	A	S
I 2 967.28	5	8R
I 2 893.6	5	5
II 47.7		8
I 03.5	4	
I 2 752.8	4	4
2 698.9	3	
I 52.0	5	2
I 2 536	10R	10R
I 34.8	4	2
I 2 482.7	3	
I 2 399.4	3	
I 78.3	3	
II 2 224.7	4	4
II 1 942	10	5
I 1 849	10	10
1 798.7		9
38.3		8
1 677.9		10
II 50		10
1 599		7
92		8
27		5
I 1 269.7		5

Ho (77, 90, 91)

λ	A	S
6 694.3	7	
29.0	10	
04.9	10	
6 550.9	10	
6 372.6	10	
05.4	10	
6 255.7	10	
34.2	10	
6 133.6	10	
6 081.8	8	
5 982.9	10	
48.0	10	
33.7	10	
21.8	10	
5 883.0	10	
60.3	10	
5 691.5	10	
74.7	10	
5 566.5	8	
4 742.0	10	3
4 649.8	8	1
29.1	8	5
4 356.72	8	8
50.73	10	5
4 254.42	10	8
4 173.22	10	
27.15	10	5
08.5	10	5
03.84	10	10
4 065.08	10	5
53.92	10	8
45.44	10	10
40.81	8	3
3 891.01	10	10
88.96	10	10
61.68		10
54.07	4	10
10.73	10	10

Ho.—(*Continued*)

λ	A	S
3 796.73	10	10
57.26	10	10
48.19	10	10
3 685.16	3	8
62.28	10	5
27.18	8	8
26.68	10	8
3 598.77	10	10
74.80	5	10
56.77	8	10
46.00	10	10
15.58	10	10
3 494.8	10	10
84.8	10	10
74.26	10	10
61.96	10	10
56.00	10	10
53.13	10	10
28.10	10	10
25.35	10	10
21.62	10	10
16.46	10	10
14.90	10	10
10.25	10	8
3 398.97	10	10
43.56	10	10
3 289.37	5	10
3 181.50	4	10
71.71	5	8
66.61	5	8
2 936.77		10R
2 774.70		10
2 433.0		10

I (91, 152, 268, 289)

λ	S	G
6 585.0		4
60.3		4
6 488.1		4
6 359.1		4
39.5		6
37.9		4
6 293.9		6
57.4		4
04.7		6
6 127.4		8
6 082.3		10
74.9		6
23.9		6
5 950.1	1	10
5 893.8		8
30.0		6
5 787.1		6
74.8	1	10
39.5		10
38.5		10
10.4	1	10
5 690.8	1	10d
78.1	1	10d
25.7	1	10
12.9		6
5 598.7		6d
5 496.9	2	10qn
93.3		8d

I.—(*Continued*)

λ	S	G
5 491.5		8d
64.7	5	10
37.9		8
35.7	1	10
07.3	1	10
05.3	1	10qr
5 369.7	1	10
45.1	3	10
38.2	3	10
09.0		8
5 269.4	1	10
65.2	1	10d
45.6	4	10
34.6		10
16.2	1	10
04.1		10
5 161.2	10	10
19.3		10
5 065.5		6
4 987.0		10
16.9		10
4 896.7		10
62.3		10
50.4		10
06.5		8
4 763.4	1	10
30.5	1	8
08.0		8
4 675.6		10
66.5		10
40.8		10
32.4	2	10
4 574.3	1	10
28.1	1	8
12.6	1	8
4 453.0	2	10
34.3	1	10
10.1	1	10
4 399.0	1	8
42.1	1	8
4 221.1	3	10
4 128.7	2	10
3 940.1		10
31.1		10
3 897.4	5	10
08.2	5	10
3 741.9	3	8
24.9	3	8
3 688.3	3	8
86.6	3	8
3 583.3	3	8
61.2	3	8
3 498.0	4	8
81.8	1	8
61.0	3	8
3 350.1	2	8
42.5	3	8
03.0	3	10
3 288.3	10	10
75.0	5	10
3 194.0	10	8
3 081.7	8	5
77.9		6

I.—(*Continued*)

λ	S	G
3 055.2	10	3
38.4	4	5
2 062.1		10
1 876.4		7
44.5		9
30.4		10
1 782.9		9
1 642.5		7
41.1		7
1 518.3		7
14.8		9
1 459.2		6
58.2		6
25.7		8
1 390.9		5
55.5		6
36.7		6
1 234.2		3

In (46, 75, 90, 91, 137, 154, 211, 251, 271)

λ	A	S
6 900.37	6	
6 891.3		10
I 47.8	8	
6 197.8		6
6 097.0		7
5 819.9	4	10
I 5 709.7	5	
5 644.87		10
5 248.6		10
4 681.9		10
56.6		10
38.9		10
I 4 511.31	10R	10
I 4 101.8	8R	10
I 3 258.54	6R	3
I 56.06	10R	8R
I 3 039.36	10R	4R
08.2		10
2 983.0		6
41.24		8
I 32.66	6R	4
2 890.23		5
36.9	8	
I 2 753.89	6R	3
I 13.94	6R	1
I 10.25	10R	3
I 2 601.8	4R	1
I 2 560.2	8R	3
I 23.9	4R	
I 21.4	8R	1
I 2 468.0	4R	
I 60.1	6R	
I 2 399.2	4R	
I 89.6	8R	
I 40.2	6R	
I 06.1	5	7
2 079.2	4	10
62.7		8
1 977.3	2	8
66.7	2	9
III 1 749.2	1	12
III 1 625.6		10

In.—(*Continued*)

λ	A	S
1 533.5		9
21.6		9
III 1 488		8
35		5
06		8
1 381		9
20		7
1 233		6
22.5		6
1 082		6
54		6
31.5		5
973		3
54.7		4
882		4
752		1
684		2
583		1
161.8		0

Ir (78, 90, 91, 127, 131, 175.1)

λ	A	S
7 834.32	5	
7 183.74	5	
7 037.85	4	
6 929.9	5	
6 893.4	4	
88.72	4	
30.06	4	
6 686.08	7	
24.74	5	
6 496.9	4	
6 334.45	6	
6 288.3	7	
11.33	4	
6 110.68	8	
6 067.85	7	
26.12	5	
5 894.09	10	
87.38	5	
82.29	9	
73.49	5	
28.54	7	
5 778.28	4	
68.89	4	
36.23	5	
09.32	6	
5 625.55	10	
20.05	6	
5 454.50	10	
49.50	10	1
5 390.98	7	
85.62	7	
64.32	10	
40.74	8	
5 273.77	6	
38.92	10	
5 177.93	8	
23.66	8	
5 046.06	8	
15.00	10	
02.70	10	
4 999.72	10	
70.46	8	

Ir.—(*Continued*)

λ	A	S
4 938.07	10	
4 778.15	4	2
4 616.37	6	2
4 426.29	6	4
4 399.48	6	8
11.50	5	4
4 268.09	4	5
59.12	4	2
4 115.80	4	5
4 069.93	4	8
33.77	4	4
20.05	5	8
3 992.14	6	6
76.33	5	10
15.38	4	6
3 895.6		8
00.10	6	6
3 747.21	5	6
34.75	2	6
31.35	4	8
3 675.00	4	4
61.72	5	3
53.20	1	6
36.22	6	3
28.69	7	5
17.23	6	4
09.78	6	3
05.83	2	10
3 573.74	6	6
22.05	6	4
15.96	6	3
13.67	9	8
3 448.99	7	4
37.05	8	4
3 368.50	8	3
34.19	5	3
3 277.28	4	2
66.45	8	3
41.52	5	3
29.28	5	3
20.79	8	5
3 198.93	5	1
68.88	5	3
33.31	6	5
20.77	5	3
00.42	8	3
3 042.63	2	6
39.25	5	3
2 951.23	5	3
43.17	7	4
36.71	5	3
34.63	6	3
24.81	8	4
2 849.74	7	4
39.18	6	2
33.23	4	10
24.44	6	4
23.18	5	2
2 774.98	2	5
12.72	4	2
2 694.22	6	3
64.77	5	3
61.99	6	3

Ir.—(*Continued*)

λ	A	S
2 543.98	5	4
12.57	2	5
2 475.11	4	2
2 372.78	4	2
2 221.1		5
2 092.7		3
51.1		5
24.4		4

K (53, 74, 90, 91, 134, 174, 192, 202, 205, 256, 261)

λ	A	S
I 85 100	1	
I 84 520	1	
I 74 260	1	
I 64 610	1	
I 310	1	
I 62 360	2	
I 030	2	
I 40 115.5	6	
I 37 370.7	1	
I 354.3	4	
I 075.6	3	
I 36 626.4	3	
I 372.7	1	
I 31 596.8	4	
I 395	8	
I 27 215.0	1	
065.6	2	
I 15 165.8	10	
I 12 523.0	9	
I 434.3	10	
I 11 771.73	10	
I 689.76	10	
I 028.0	10	
I 9 590	1	
I 8 908	1	
I 8 500	1	
7 931		
I 7 699.01	10R	5R
I 64.94	10R	5R
I 6 939.0	10	6
I 11.3	10	4
I 5 832.0	7R	4
I 12.4	6R	3
I 01.9	6R	4
I 5 782.6	5R	3
I 5 359.7	5R	2
I 43.2	4R	1
I 39.9	4R	2
I 23.4	4R	1
I 5 112.5	3R	1
I 5 099.3	3R	1
I 97.6	2R	
I 84.3	2R	1
05.58		5
I 4 965.3	1R	
I 56.6	1R	
I 52.0	1R	
I 42.9	1R	1
4 608.43		6
4 505.34		5
4 466.66		4
4 388.13		5

K.—(*Continued*)

λ	A	S
4 309.0		5
4 263.3		8
25.6		4
23.0		5
4 186.1		10
49.2		5
34.7		5
I 4 047.22	10R	10R
I 44.16	10R	10R
01.2		5
3 897.9		8
3 681.5		4
18.43		5
08.88		5
3 530.71		8
I 3 447.38	6R	2
I 46.37	8R	3
40.4		3
3 385.3		4
81.1		4
64.7		6
63.3		8
45.7		5
I 3 217.6	4R	1
I 17.2	6R	1
I 3 102.2	2R	
I 02.0	4R	1
3 062.4		5
I 34.8	4Rd	
I 2 992.2	1Rd	3
I 63.2	1R	
I 42.7	1R	
2 550		5
2 358		3
2 241		5
2 190		6
2 078		10
1 944		5
1 787		4
71		6
03		9
1 669		4d
765.7		3
612.5		3
470.4		4
382.5		2

Kr (7, 156, 187, 201, 238)

λ	G_c*	G_o*
8 928.72	1	
8 776.73	3	
8 508.85	2	
8 298.07	6	
81.02	3	
63.22	4	
8 190.02	6	
12.89	10	
04.33	7	
8 059.47	4	
7 854.81	7	
7 694.53	8	

* G_c = with condenser (Leyden jar); G_o = without condenser.

Kr.—(*Continued*)

λ	G_c	G_o
7 685.22	7	
01.55	10	
7 587.40	10	
6 904.6	5	
6 456.3	5	
6 056.1	2	
5 870.917	10	
5 681.9		5
60.1	3	
33.0		6
5 570.291	10	
62.2	6	
19.4	4	
5 498.0	3	
4 829.7	3	
07.0	4	
4 765.7		6
62.45		5
38.96		7
34.1	4	
4 694.9		4
80.5		4
71.23	10	
58.9		5
33.88		5
24.28	10	
19.12		6
15.30		5
4 582.7	4	4
77.2		6
56.6		4
24.6	4	
23.1		5
02.2	9	
01.0	7	
4 489.9		4
75.0		4
63.68	10	
53.91	10	
36.80		4
4 399.9	6	
76.1	10	
62.6	9	
55.47		10
19.58	10	
18.55	8	
18.0		5
00.5		5
4 292.94		6
82.97	4	
73.97	10	
4 145.12		6
09.2		6
4 098.7		7
88.36		8
65.05		8
57.01		8
50.5		5
44.6		5
3 997.9		5
94.8		6
54.7		5
20.4		8

Kr.—(*Continued*)

λ	G_c	G_o
3 917.6		6
12.3		5
06.2		8
3 894.7		5
75.4		7
63.8		5
60.4		5
3 796.9	4	
83.2		10
78.11		10
54.2		5
44.8		9
41.69		10
35.8		5
21.3		7
18.6		8
18.0		10
3 690.6		5
86.1		6
80.4		7
79.5	4	
69.0		9
53.96		10
31.9		10
07.9		9
3 599.9		6
89.6		7
35.3		6
07.4		9
03.2		6
3 488.6		8
74.6		7
70.0		7
60.1		6
46.5		7
39.5		6
05.1		7
3 351.9		6
30.7		7
25.7		9
20.3		10
11.5		6
3 268.5		7
64.8		8
45.7		10
40.4		6
39.5		6
07.8		8
00.4		6
3 191.2		6
89.1		7
41.3		6
24.4		6
3 063.1		5
46.9		5
2 967.3		5
2 892.2		5
33.0		6
16.5		6
2 795.8		5
12.4		8
2 681.2		4
48.2		4

Kr.—(*Continued*)

λ	G_e	G_o
2 639.8		4
20.4		4
2 592.5		5
06.6		9
2 478.9		4
64.8		8
59.6		7
57.7		8
56.1		8
53.3		6
52.3		6
46.5		8
42.6		7
39.2		8
28.3		10
26.4		9
20.2		10
18.2		10
15.0		9
13.9		9
09.1		8
08.5		7
06.3		6
2 398.3		10
94.0		8
92.8		7
75.6		10
71.5		8
62.9		8
59.9		10
44.5		8
29.2		8
20.8		6
16.2		10
15.4		9
14.1		8
11.9		8
01.6		8
00.3		8
2 287.7		10
82.8		10
77.4		7
73.1		6
45.3		6
37.0		5
27.9		6

La (61, 74, 77, 78, 90, 91, 145, 229, 286)

λ	A	S
8 748.42	2	
8 674.38	3	
8 545.43	3	
8 346.55	3	
24.69	3	
7 483.48	4	
7 345.34	4	
34.17	5	
7 282.33	5	
7 161.22	4	
7 068.34	4	
66.21	5	
6 925.26	3	
6 774.28	6	3

La.—(*Continued*)

λ	A	S
6 753.07	4	
09.51	4	
6 671.41	4	2
61.41	4	1
50.81	4	
16.60	4	
6 578.54	5	3
43.17	8	1
26.98	8	4
6 456.00	5R	3
54.53	6	1
11.00	10	3
6 399.04	5	5
94.24	6R	6
90.48	5R	7
25.93	5R	1
20.39	5R	5
6 296.11	5R	5
93.60	4R	2
66.06	4R	1
62.29	5R	6
49.94	7R	5
6 165.73	5R	
34.42	5R	
29.57	5R	3
26.09	4R	3
11.74	4R	
08.49	5R	
6 068.74	4R	
38.59	4R	
5 930.59	6R	3
5 894.83	4R	
80.63	5R	2
63.70	5R	2
55.59	4R	
48.36	4R	
45.03	4R	
29.73	4R	
23.83	4R	
21.99	6R	1
08.32	5R	1
05.76	5R	2
5 797.59	7R	2
91.33	7R	1
89.23	6R	1
69.97	5R	
69.35	7R	1
69.07	7R	3
61.84	5R	1
44.41	5R	
40.65	6R	1
5 648.25	5	
5 588.34	4R	
41.26	4R	
01.35	6R	1
5 464.39	5	1
55.14	6	1
5 301.96	5	1
5 183.41	8	5
22.96	5	3
14.54	6	3
06.22	6	1
4 999.46	6	3
86.83	6	2

La.—(*Continued*)

λ	A	S
4 921.80	7	5
20.98	7	5
4 899.92	7	4
60.90	6	3
24.06	6	4
09.00	6	3
4 748.72	6	5
43.08	8	10
40.27	8	5
28.41	7	3
4 692.49	5	5
71.81	4	5
68.90	5	8
63.76	5	8
62.51	6	4
55.49	7	10
19.83	5	6
13.38	6	5
4 580.06	6	3
74.85	8	5
70.02	6	1
67.90	6	1
58.45	7	5
49.50	6	1
26.11	8	8
25.29	6	8
22.38	9	10
4 452.17	6	1
29.90	10	10
27.56	7	8
4 385.18	5	4
83.45	6	8
78.09	7	4
54.39	8	10
34.97	6	8
33.80	10	10
22.53	6	5
4 296.06	9	8
86.95	8	10
75.64	4	4
69.49	6	10
63.59	6	8
49.99	5	6
38.39	10	10
30.95	4	6
17.55	6	10
04.04	5	4
4 196.55	10	10
92.34	7	8
52.78	4	5
51.97	8	10
41.75	10	10
23.23	10	10
4 099.55	7	10
86.71	10	10
77.35	10	10
67.39	6	8
50.09	6	10
42.92	8	10
31.70	7	10
25.87	6	4
3 995.75	10	5
88.52	10	10
49.10	10	10

La.—(*Continued*)

λ	A	S
3 929.21	8	10
21.54	7	10
16.03	7	10
3 886.34	7	10
71.63	8	10
49.00	6	10
40.70	5	5
3 794.76	8	10
90.82	8	10
59.07	8	10
15.52	5	4
13.55	5	6
3 650.17	5	4
45.41	6	8
3 517.1		10
3 380.91	8	10
44.56	8	7
37.49	8	10
03.11	6	5
3 265.65	6	4
49.35	5	3
45.12	6	4
3 171.7		10
2 808.36	5	3
2 651.7		8
10.34	4	5
2 476.7		7
2 379.4		10
2 297.8		7

Li (61, 90, 91, 123, 134, 174, 205)

λ	A	S
I 74 360	1	
I 40 475	1	
26 891	1	
I 875	2	
I 24 467	8	
23 991	2	
I 19 290	1	
18 697	5	
I 17 552	2	
13 566	2	
I 12 782	2	
I 232	1	
I 8 126.4	10	
I 6 707.86	10R	10R
I 6 240.6	1	
I 6 103.6	10R	10
I 4 971.9	7	4
I 4 636	3	
I 03.0	9R	10
I 02.0	9R	10
I 4 273.3	5	2
I 4 148		
I 32.3	5	1
I 3 985.7	3	
I 15	2R	1
I 3 794	5	
I 19	3	
I 3 232.7	8R	3R
I 2 741.3	6R	2R

Li.—(*Continued*)

λ	A	S
I 2 562.5	5R	
I 2 475	4R	
25.6	3R	
I 2 394.4	1R	

Lu* (65, 76, 90, 91, 130)

λ	A	S
7 125.85	7	
7 031.18	4	
6 917.28	7	
6 793.80	5	
6 523.16	10	
6 463.16	10	3
6 345.44	7	
6 242.42	7	1
35.39	5	1
21.88	10	4
6 199.73	5	
60.00	6	1
6 055.05	6	
04.54	10	1
5 984.11	10	1
83.65	10	1
5 775.39	6	
36.54	10	1
5 476.70	10	10
02.57	10	1
5 135.11	10	1
5 001.14	6	1
4 994.13	10	3
04.87	5	1
4 839.52	4	1
4 785.45	5	3
4 658.00	10	3
4 518.54	10	5
4 296.02	5	1
81.03	5	1
4 184.24	10	10
24.73	10	5
4 054.46	5	2
3 876.65	10	10
41.15	7	2
3 684.34	4	
47.77	5	2
36.26	10	3
23.97	10	10
3 567.84	10	5
54.43	10	10
44.93	5	
08.41	10	3
07.40	10	10
3 472.49	10	10
3 397.02	10	10
76.54	10	5
59.59	10	5
12.12	10	5
3 281.75	10	5
78.96	10	4
54.31	10	10
3 198.13	10	10
91.78	2	10
18.42	7	3

* This list is more or less uncertain.
Lutecium = Cassiopeium = Celtium.

Lu.—(*Continued*)

λ	A	S
3 081.48	9	3
77.62	10	10
57.96		10
56.74	10	10
20.56	4	10
2 969.81	6	10
63.33	7	10
51.68	3	8
11.40	10	10
00.32	10	10
2 894.86	10	10
47.50	5	10
2 796.64	4	10
72.60		10
54.19	4	10
2 657.83	4	10
15.42	10	10
03.32		10
2 578.79	4	5

Mg (47, 72, 90, 91, 97, 98, 100, 111, 132, 158, 174, 198, 203)

λ	A	S
I 23 991	1	
I 977	1	
I 963	1	
I 17 108	6	
I 15 768	4	
I 759	1	
I 028	6	
I 14 877	10	
I 12 083	5	
I 11 828	10	
054?	2	
I 10 970	3	
I 963	1	
I 813	3	
I 9 258	3	
24	1	
I 8 929	2	
I 8 806.8	5	
II 7 896.3		5
II 77.1		4
I 7 658	2	
II 6 347.1	4	
I 18.5	2	
I 5 711.13	5	1
I 5 528.48	10	5
I 5 183.602	10R	10
I 72.680	10R	10
I 67.33	8R	10
II 4 851.1		5
II 4 739.6		5
I 03.07	10	5
I 4 571.12	5	2
II 4 481		10
II 34.0		8
II 28.0		7
II 4 390.6		10
II 84.6		8
I 51.9	8	2
I 4 167.6	4	1
II 3 850.4		6

Mg.—(*Continued*)

λ	A	S
II 3 848.2		7
I 38.29	10R	10R
I 32.17	10R	10R
I 29.36	8R	10R
II 3 538.8		6
II 35.0		5
I 3 336.69	10	8
I 32.17	10	5
I 29.94	8	3
II 3 104.8		10
II 04.7		10
I 3 096.92	10R	2
I 93.05	8R	2
I 91.09	8R	1
I 2 942.06	6	2
I 38.5	5	
I 36.8	4	
II 36.6	4	10R
II 28.7	3	10
15.5	3	8
I 2 852.130	10R	10R
I 48.42	5	1
I 46.78	4	1
II 02.712	10R	10R
II 2 798.0		10
II 95.540	10R	10R
II 90.83	4	10R
82.988	6R	6R
I 81.43	6R	6R
I 79.85	8R	8R
I 78.29	6R	6R
I 76.71	6R	6R
I 36.6	4	1
I 33.55	4	1
I 2 698.2	5	
I 95.3	4	
I 93.8	2	
I 72.6	8	
I 69.7	6	
I 68.2	3	
II 60.82		5
II 60.76		5
I 2 026	6	6
1 931	6	
1 886	5	
64	4	
56	5	
I 28	3	
II 1 753.6		6
II 50.9		5
44	5	
41	5	
II 37	2	7
II 35	1	6
323.2		4
20.9		5
231.6		2

Mn (39, 54, 75, 90, 91, 103, 146, 154, 226, 267, 285)

λ	A	S
17 608	2	
336	8	
15 965	10	

Mn.—(*Continued*)

λ	A	S
15 263	10	
218	8	
14 970	3	
I 13 997	10	
I 864	10	
685	8	
I 626	10	
500	10	
416	8	
I 318	3	
I 294	5	
12 976	4	
I 900	8	
307?		
11 782	6	
614	4	
378	2	
I 8 740.9	3	
I 03.7	3	
I 8 672.1	2	
I 70.8	2	
54.6	2	
8 212.4	2	
7 942.9	2	
7 821.3	2	
7 764.8	5	
12.4	5	
10.2	5	
7 680.20	5	
46.34	3	
7 326.55	7	
02.92	6	
7 283.80	6	
47.83	5	
7 184.29	5	
51.33	8	
7 069.86	4	
6 989.94	4	
42.55	5	
6 605.57	4	
6 491.71	7	
40.97	5	
6 382.19	3	
6 078.40	3	
I 21.79	10	1
I 16.64	10	1
I 13.50	10	1
5 848.97	3	
5 780.17	5	
38.28	4	
5 567.765	4	1
51.99	5	1
I 37.748	7	2
I 16.773	8	2
05.877	6	1
I 5 481.397	6	1
I 70.639	8	2
32.555	6	1
I 20.366	7	3
13.696	7	2
I 07.432	7	2
5 399.506	8	3
94.677	7	2

Mn.—(*Continued*)

	λ	A	S
	5 377.634	8	3
I	41.071	10	8
	5 255.330	5	2
	5 196.603	5	1
	4 965.856	5	1
I	4 823.523	10	4
I	4 783.433	10	4
I	66.424	6	3
I	65.859	5	2
I	62.375	9	4
I	61.527	5	2
I	54.048	10	8
I	39.002	5	2
I	27.462	7	2
I	09.704	7	2
	4 626.54	5	2
I	4 502.221	7	4
I	4 498.900	7	4
I	90.09	5	3
I	72.80	7	3
I	70.143	7	4
I	64.681	7	5
I	62.033	9	8
I	61.092	6	4
I	58.265	6	5
I	57.554	6	4
I	57.041	5	2
I	55.823	5	3
I	55.320	6	3
I	55.019	6	3
I	53.012	5	3
I	51.59	9	3
I	36.357	7	5
I	14.87	8	6
	4 374.942	4	2
I	4 281.097	5	5
I	65.919	5	5
I	57.668	5	4
I	39.729	5	5
I	35.29	8	10
I	35.144	8	
	4 189.99	4	4
	76.60	4	4
	31.12	4	4
I	4 083.638	6	6
I	82.947	6	6
I	79.43	6	5
I	79.25	6	5
I	55.554	8	8
I	48.760	4	8
	45.20	4	5
I	41.366	8R	10
I	35.730	5R	8
I	34.489	8R	10R
	33.63	3R	3
I	33.074	8R	10R
I	30.760	6R	10R
I	18.105	8	8
	3 985.24	4	3
I	3 843.99	6	4
I	41.09	4	6
I	39.77	4	5
I	34.36	6R	8
I	33.865	6	4

Mn.—(*Continued*)

	λ	A	S
I	3 823.897	4	4
I	23.512	4R	6
I	09.599	6	6
I	06.86	6	8
I	3 610.30	6	3
I	08.48	6	3
I	07.520	8	3
I	3 586.55	5	5
I	77.881	8R	5
I	70.102	4R	3
I	69.799	8R	4
I	69.495	6R	5
I	48.187	4R	3
I	48.022	4R	3
I	47.792	5R	4
I	32.11	5R	3
I	31.999	5R	3
I	31.838	4R	2
I	3 495.840	5	6
I	88.686	4	10
I	82.918	4	10
I	74.139	4	10
I	60.330	3	10
I	41.997	5	10
	3 330.674	4	3
	20.698	4	1
	17.30	6u	1
I	3 258.420	4	2
I	56.141	4	2
I	48.521	4	3
I	43.785	4	2
I	36.786	6	3
	28.099	5	3
I	12.893	6	2
I	3 178.528	8	1
I	48.190	4	1
	10.69	5	1
I	3 079.63	5	1
I	62.13	4	1
I	54.38	4	2
I	44.570	4	2
II	2 949.21	6	10
I	40.39	6	1
II	39.31	6	10
II	33.06	6	10
I	25.59	6d	1
I	14.61	8d	1
	2 889.52	3	10
	86.68	2	6
	79.49	1	5
I	01.080	6R	5R
I	2 798.271	6R	5R
I	94.821	6R	5R
	11.6		5
	05.74	2	8
	01.70	3	5
	2 695.36	1	5
	72.58	1	5
	55.8		5
	38.17	1	5
	32.35	1	8
	25.6		8
	18.15	4	8
II	05.69	5R	10R

Mn.—(*Continued*)

	λ	A	S
II	2 593.733	4R	10R
	92.95	5	1
II	76.12	5R	10R
	75.51	5	1
II	2 452.52	2R	10
	1 993		5
	52.1		3
	04		5
	1 892.0		4
	1 789		10
	1 573(?)		5
	1 438		5
	1 118		5
	13		5
	893		10
	648		2
	311		1

Mo (74, 75, 78, 90, 91, 115, 146, 154, 157, 221, 281)

	λ	A	S
	9 348.01	2	
	8 695.53	2	
I	8 389.28	6	
I	28.43	5	
I	8 245.06	3	
	7 720.74	4	
I	7 656.74	5	
I	7 485.73	7	
I	7 391.36	5	
	7 245.87	4	
I	42.54	7	
I	7 134.09	4	
I	09.87	8	
I	7 060.23	4	
	6 989.01	4	
	14.05	5	
	6 886.37	4	
	38.95	4	
	6 746.28	5	1
I	33.99	7	1
	6 650.38	7	1
I	19.15	9	8
	6 519.84	4	3
	6 424.37	8	8
	6 357.21	5	3
I	6 030.66	9	10
I	5 928.82	9	10
I	5 888.32	10	10
I	58.28	8	10
I	5 791.84	10	10
I	51.42	10	10
I	22.77	8	7
I	5 689.15	9	10
I	50.13	8	6
I	32.47	9	8
I	5 570.46	10	10
I	33.03	10	10
I	06.50	10	10

Mo.—(*Continued*)

	λ	A	S
	5 473.35	6	6
I	5 360.59	10	8
I	5 240.94	6	3
I	38.20	7	3
I	5 174.15	9	2
I	72.94	9	1
	4 979.12	5	2
	4 868.03	5	2
	30.52	10	4
	19.26	10	4
	4 760.20	9	9
	31.45	10	7
	07.25	10	5
I	4 626.45	10	4
	21.35	7	2
I	4 595.15	7	2
I	76.49	8	2
I	24.34	7	2
	4 491.29	6	2
	68.27	10	2
	34.96	10	4
II	33.51	1	8
	11.71	10	8
	4 381.65	10	8
II	77.76	1	10
II	63.65	1	10
	26.14	9	4
I	4 293.89	9	3
I	93.24	10	4
I	92.21	9	4
II	79.03	2	10
I	77.26	10	6
	76.92	10	5
	51.86	10R	2
	50.69	1	10
	32.61	10	5
	4 188.32	10	5
	85.82	8	4
	43.56	9	5
I	02.16	7	3
	4 084.39	8	3
	69.91	9	8
	3 961.49	3	10
II	41.50	1	10
I	02.96	10R	10
I	3 864.12	10R	10
	33.76	7	3
I	3 798.26	10R	10R
II	02.56	2	8
II	3 692.66	2	9
II	88.33	1	10
	51.14	1	8
	35.15	2	10
	14.25	8	3
	3 524.62	2	7
	04.41	6	2
	3 447.13	10	3
	02.81	1	8
I	3 384.62	8	2
I	58.12	9	2
	47.02	6	1
	44.75	8	2
I	27.30	10	1
	25.67	10	1

Mo.—(*Continued*)

	λ	A	S
	3 292.32	1	10
	08.85	10	2
I	3 193.98	10R	2
I	70.35	10R	2
	58.16	9R	2
I	32.60	10R	2
	21.99	2	10
	16.08	1	8
	3 087.61	2	10
II	2 923.40	4	10
II	11.91	5	10
	03.07	2	10
II	2 871.50	4	10
	53.19	1	10
II	48.21	5	10
II	16.15	5	10
	2 780.04	3	10
	75.40	3	10
II	01.42	2	10
II	2 684.13	3	10
	72.84	2	10
II	60.58	2	10
II	44.33	2	10
II	38.75	3	10
	2 538.46	2	10
	1 809.8		7
	697		4
	692		2
	548		4
	377		1

N (32, 34, 49, 91, 95, 99, 141, 142, 162, 188, 191, 199, 219, 255)

λ	G
8 729.07	1
18.99	1
11.87	1
03.42	1
8 686.38	1
83.61	2
80.35	2
29.61	2
8 594.34	1
68.04	1
8 242.47	3
23.28	3
16.46	5
10.94	2
00.59	1
8 188.16	3
85.05	3
I 7 468.74	5
I 42.56	4
I 23.88	3
I 6 722.60	5
I 6 644.97	7
10	4
I 6 484.88	8
I 83.77	4
I 82.74	9
I 41.70	5
I 6 008.49	9

N.—(*Continued*)

	λ	G
I	5 999.46	5
II	41.9	7
II	31.9	4
II	5 686.2	5
II	79.5	10
II	75.9	5
II	66.5	10
	5 543.4	3
	35.2	6
	30.2	4
II	5 495.9	6
	62.7	3
I	5 328.67	5
	5 179.5	4
II	5 045.0	6
II	25.6	3
II	15.4	3
II	10.6	3
	07.4	3
	05.1	6
II	01.34	7
	4 994.4	4
	87.3	4
I	35.03	9
I	14.92	4
	4 895.3	3
III	67.14	4
III	58.82	3
II	10.3	3
II	03.3	5
II	4 793.8	3
II	88.2	4
II	79.8	3
II	74.2	3
	4 667.2	3
II	54.5	3
II	43.0	9
III	40.6	6
III	34.1	6
II	30.5	8
II	21.4	7
II	13.9	6
II	07.1	7
II	01.5	7
	4 552.4	4
	30.0	6
III	14.8	4
III	10.8	4
I	4 494.68	5
I	92.45	5
	47.0	10
	32.6	5
III	4 379.0	8
I	58.29	7
I	05.46	6
	4 241.8	8
II	36.9	8
II	27.7	4
I	23.09	5
	06.5	4
	00.0	5
III	4 195.7	3
	79.7	3
	76.1	5

N.—(*Continued*)

	λ	G
	4 171.6	4
I	51.44	9
	45.8	4
	33.6	3
I	09.94	10
III	03.4	7
III	4 097.3	10
II	43.5	3
	41.3	7
II	35.0	5
	26.0	4
II	3 995.0	10
II	55.8	7
	40.0	3
	19.0	6
	3 870.0	4
II	56.1	3
II	42.8	3
	39.0	4
II	30.0	6
I	22.0	5
I	3 650.1	5
II	3 437.1	7
II	3 329.2	3
II	3 006.8	7
I	1 745.31	5
I	42.81	5
	1 657.2	7
	1 561.1	7
I	1 494.78	3
I	92.83	3
	1 335.3	10
II	1 276.0	10tr
V	42.2	4
	00.4	10
	1 184.1	10
	1 085	10qr
III	991.66	3
III	89.90	2
IV	24.31	
IV	23.68	
IV	23.18	
IV	22.57	
IV	22.02	
II	16.82	2qr
III	685.5	5qr

Na (61, 81, 90, 91, 134, 174, 192, 202, 205, 256, 261, 288)

	λ	A	S
I	90 850		4
I	480		3
I	74 430	1R	
I	40 449	8R	
I	18 459.5	10	
I	11 404.2	10	
I	382.4	10	
I	8 194.93	10	
I	83.33	8	
I	6 160.8	5	4
I	54.4	4	3
I	5 895.932	8R	10
I	89.965	10R	10
I	5 688.3	10	8r

Na.—(*Continued*)

	λ	A	S
I	5 682.8	8	8r
I	75.8		8
I	4 983.2	6r	4r
I	79.0	5r	4
I	4 752.0	4u	2r
I	48.1	3u	2
I	4 669	4r	3u
I	65	3r	3u
I	4 393	3	1
	3 711		3
	3 631		5
	3 533.1		8
I	3 302.94	8R	8R
I	02.34	9R	9R
	3 285		5
	3 189		4
	29		6
	3 093		6
	78.5		4
	56.3		3
	2 984.3		4
	80		4
	51.4		5
I	2 853.0	4R	5
I	52.8	5R	
	47		4
I	2 680.4	3R	4
I	80.3	4R	
I	2 593.9	2R	3
I	93.8	3R	
I	43.9	1R	1
I	43.8	2R	
I	12.2	1R	1
I	12.1	1R	
	2 493.3		2
	90.7	1R	
	1 787.4		4
	73.5		6
	70.8		6
	49.3		8
	03.5		9
	1 698.9?		10
	69.3		4
	68.7		4
	59.7		4
	376.6?		1
	372.3		2

Nb, *see* Cb

Nd (11, 62, 78, 90, 91)

λ	A	S
8 456.80	3	
8 375.23	3	
8 143.29	4	
41.72	4	
8 043.33	4	
00.75	4	
7 982.34	4	
65.69	4	
58.93	4	
7 862.84	4	
08.53	4	
7 696.60	4	
7 538.27	4	

Nd.—(*Continued*)

λ	A	S
7 529.03	4	
13.77	4	
11.15	4	
7 448.73	4	
18.18	4	
7 189.41	4	
29.36	4	
7 066.90	4	
37.34	4	
6 846.74	5	
03.98	4	
6 790.42	4	
40.10	4	
6 655.67	4	
50.56	4	1
30.16	4	
6 485.69	4	1
6 385.18	8	3
41.48	7	2
10.48	7	1
6 178.55	4	1
6 073.97	4	
71.70	4	
66.05	4	
07.63	4	
5 804.00	5	2
5 729.28	4	
08.25	5	2
5 688.49	6	3
20.58	8	5
5 594.40	8	5
5 485.68	7	4
31.53	4	3
5 361.47	5	4
19.80	9	4
5 293.17	9	5
49.54	7	4
5 192.62	6	3
4 920.66	9	3
4 859.01	5	5
25.47	8	8
11.33	5	5
4 706.54	7	4
4 634.21	5	3
4 579.30	5	4
63.21	6	5
41.25	5	5
01.82	7	5
4 462.96	10	10
51.55	10	10
46.37	10	10
11.03	8	5
00.84	10	5
4 385.68	10	8
75.00	10	6
58.20	9	8
51.23	9	8
27.93	7	5
25.77	10	5
14.50	7	8
03.61	10	10
4 282.51	10	8
47.37	10	8

Nd.—(*Continued*)

λ	A	S
4 232.40	8	5
4 178.68	6	3
77.34	9	10
56.16	10	10
35.33	9	7
09.47	9	8
09.09	8	6
4 075.24	7	2
69.26	5	4
61.09	10	10
21.76	7	3
12.28	9	10
3 994.70	8	5
90.13	9	6
63.12	7	6
51.15	9	8
41.53	7	8
05.90	7	4
00.25	6	6
3 894.65	6	3
92.06	6	4
90.96	7	4
90.59	6	4
89.95	6	3
75.85	6	2
63.37	10	8
51.73	8	5
3 780.40	5	3
35.59	7	5
3 653.10	6	2
09.78	5	1
3 592.58	5	2
43.33	5	2
3 410.21	4	1
3 388.01	5	1
28.26	5	2
00.14	4	2
3 275.20	4	2
17.10	4	1
3 133.56	4	2
3 092.91	4	2

Ne (7, 41, 44, 180, 181, 194, 209, 220, 275, 277)

λ	G
9 300.70	2
9 220.28	2
01.88	2
9 148.72	2
8 865.72	3
53.97	3
8 783.75	4
80.63	4
8 681.86	3
79.52	3
54.380	6
34.63	5
8 591.25	6
8 495.37	7
18.41	7
8 377.62	7
00.35	7
8 266.02	5
59.36	4

Ne.—(*Continued*)

λ	G
8 236.42	7
8 136.41	4
8 082.46	8
7 943.19	8
7 544.052	8
35.784	8
7 488.887	5
72.455	6
38.89	8
7 245.165	10
7 173.938	10
7 059.115	4
51.30	4
32.411	6
24.046	6
6 929.466	9
6 717.043	5
6 678.276	8
6 598.953	8
32.883	5
06.528	10
6 444.70	6
21.68	5
09.71	6
02.246	10
01.08	5
6 382.991	10
64.96	5
51.8	5
34.428	9
30.89	6
28.15	7
13.65	6
04.789	5
6 293.7	5
66.495	10
58.78	5
46.71	5
17.281	9
13.88	6
05.76	5
6 182.15	5
63.594	8
50.27	5
43.062	10
42.51	5
28.45	6
6 096.163	8
74.338	9
29.997	7
00.95	5
5 991.68	6
87.93	7
75.534	8
74.64	9
65.44	10
61.63	5
44.834	9
39.32	5
18.92	7
13.63	7
06.44	5
02.48	5

Ne.—(*Continued*)

λ	G
5 881.895	10
72.84	9
72.17	5
68.4	5
52.488	10
28.91	6
20.17	9
11.42	7
04.45	9
04.10	6
5 764.42	9
48.65	6
48.29	9
19.53	6
19.22	9
18.90	7
5 689.81	7
62.55	6
56.66	8
56.03	5
52.57	5
5 563.05	5
62.76	8
62.44	6
33.68	5
5 448.51	6
33.65	7
18.56	6
12.66	7
00.56	10
5 372.31	5
60.02	6
58.02	10
55.40	6
55.18	6
49.21	6
43.29	9
41.097	10
30.78	10
26.41	5
01.77	5
5 298.20	6
08.87	5
03.90	6
5 193.23	6
93.12	6
88.61	6
51.96	5
45.01	8
44.93	8
22.34	6
22.25	6
16.49	6
13.66	5
5 080.38	6
37.74	8
31.34	7
05.15	8
4 994.92	5
57.12	5
57.03	8
55.38	5
4 892.08	7

Ne.—(*Continued*)

λ	G
4 884.91	8
37.31	7
27.59	6
27.34	8
21.93	6
18.79	5
17.64	6
10.07	5
4 790.22	8
88.93	10
80.34	6
58.72	5
52.73	8
49.56	6
15.34	10
12.06	8
10.06	8
08.86	10
04.39	10
02.53	5
4 679.13	5
78.21	6
61.09	5
56.38	6
45.41	6
28.30	7
09.91	7
4 582.45	5
82.05	5
75.86	10
75.06	6
40.38	8
38.31	6
37.76	10
37.68	6
36.31	5
4 488.09	6
83.19	5
25.42	5
24.81	6
22.52	6
3 727.3	6
13.3	9
01.22	7
3 694.4	9
85.73	7
82.23	7
64.3	7
33.660	6
09.17	5
00.16	6
3 593.632	7
93.522	8
74.9	6
68.7	8
20.470	10
15.189	6
01.214	6
3 498.063	5
72.573	8
66.578	6
64.337	5
60.524	5

Ne.—(*Continued*)

λ	G
3 454.195	6
47.703	7
17.903	8
3 369.905	10
69.81	8
55.2	6
35.1	7
3 148.60	5
26.19	6
3 079.18	5
78.87	5
76.97	6
63.69	6
57.39	7
2 992.44	6
92.42	6
82.66	7
74.71	7
47.30	6
32.72	5
13.17	6
2 872.66	5
2 795.10	5
2 675.64	6
75.24	6
51.01	6
47.42	8
45.70	5
45.51	6
2 595.21	6

Ni (8, 12, 54, 75, 87, 90, 91, 109, 114, 177, 193, 212, 216, 226)

λ	A	S
18 040	2	
17 986	2	
16 999	6	
868	2	
495	2	
409?	5	
363	10	
313	2	
14 874	3	
102	2	
13 969	2	
829	3	
722	5	
553	2	
11 591	3	
198	4	
10 980	5	
378	4	
330	3	
301	3	
195	5	
I 9 519.99	2	
9 106.33	3	
I 8 862.60	4	
I 7 917.47	7	
I 7 863.70	5	
I 7 797.66	8	
I 88.95	6	
48.94	10	

Ni.—(*Continued*)

λ	A	S
I 7 727.68	10	
I 15.64	7	
I 14.27	8	
I 7 619.24	9	
I 17.02	10	
I 7 574.10	7	
I 55.67	9	
I 25.18	8	
I 22.87	8	
I 7 481.49	5	
I 22.34	9	
I 14.51	6	
I 09.35	9	
I 7 393.67	10	
86.24	7	
85.23	7	
I 7 291.30	8	
I 61.94	8	
I 7 197.07	4	
I 82.06	9	
I 22.29	10	
I 7 024.76	8	
I 6 914.58	7	
I 6 842.08	6	
I 6 772.36	9	
I 67.79	10	
I 6 643.66	10	1
35.14	6	
I 6 598.54	6	
I 86.33	6	
I 6 482.84	7	1
21.47	7	
I 6 384.69	7	
I 78.22	7	
I 39.17	10	
I 14.66	10	
I 6 256.39	7	1
I 23.97	6	
I 6 191.23	7	1
I 86.77	7	
76.80	10	2
I 75.44	10	1
63.36	8	1
I 16.16	9	1
I 08.14	7	1
I 6 086.34	10	1
I 5 892.882	9	1
I 57.759	10	1
31.60	8	
I 05.20	10	
I 5 760.84	6	1
I 54.67	6	1
I 15.09	8	1
I 09.55	8	2
5 694.97	7	1
82.20	7	1
25.28	7	1
I 14.79	6	1
I 5 593.74	6	1
I 92.24	7	2
I 5 476.91	10	10
I 35.87	7	1
11.20	6	1

Ni.—(*Continued*)

λ	A	S
5 176.55	6	1
I 68.66	8	1
I 55.76	9	1
I 46.48	10	2
I 42.76	10	2
I 37.09	8	1
I 29.38	8	1
I 25.20	7	
I 15.42	9	2
I 5 099.97	7	1
84.07	6	1
81.12	9	3
80.53	8	3
I 35.36	10	3
I 17.59	7	2
I 4 984.12	9	2
80.17	9	2
04.42	9	3
I 4 866.28	7	2
I 55.42	8	3
I 31.19	5	3
I 29.03	8	3
I 4 786.542	10	3
I 56.526	7	3
I 15.757	8	3
I 14.420	10	8
I 4 686.21	5	3
I 48.655	10	3
I 04.991	9	3
I 00.366	8	1
I 4 592.535	9	4
I 4 470.484	9	3
I 62.462	8	3
I 59.044	9	8
I 01.551	10	8
I 3 858.33	10	8
I 31.690	6	2
I 07.14	8	8
I 3 783.53	8	5
I 75.57	8	5
I 36.812	6	3
I 22.48	6	1
I 3 674.13	6	3
I 19.392	10	10
I 10.47	9	4
I 3 597,700	8R	6
I 71.872	7R	3
I 66.375	10R	10
I 24.539	10R	10
I 15.056	9R	10
I 10.339	7R	10
00.852	6	4
I 3 492.962	10R	10
I 83.781	6R	4
I 72.55	7R	5
I 61.661	10R	10
I 58.467	10R	10
I 52.891	6R	5
I 46.262	10R	10
I 37.281	6R	5
I 33.57	9R	6
I 23.710	8R	5
I 14.77	10R	10

Ni.—(*Continued*)

	λ	A	S
I	3 413.940	3R	2
I	13.480	5R	3
I	3 392.992	10R	8
I	91.051	7R	4
I	80.883	4R	2
I	80.577	10R	6
I	74.224	4R	2
I	71.993	5R	3
I	69.57	10R	4
I	66.170	5R	3
I	65.771	4R	3
I	61.558	5R	3
I	20.259	5R	3
I	15.669	7R	3
I	3 243.064	8R	3
I	34.656	5R	2
I	32.944	8R	3
I	25.030	5R	2
I	21.660	4R	2
I	3 197.120	5	2
I	34.104	10R	4
I	01.880	9R	3
I	01.561	9R	4
I	3 097.121	5	2
I	80.757	6	2
I	64.625	6	2
I	57.648	10R	4
I	54.318	8R	4
I	50.825	10R	6
I	37.939	9R	4
I	12.007	9R	5
I	03.627	9R	4
I	02.491	10R	5
I	2 994.46	7R	3
I	92.599	6	2
I	81.652	7	3
I	43.922	6	2
I	2 821.296	4	2
I	2 798.66	4	1
	2 545.92	1	6
	10.89	4	10
	2 437.90	1	10
	16.14	1	10
	2 394.56	2	10
	75.43	1	8
I	45.53	2R	8R
I	25.81	3R	2
I	20.08	5R	1
I	12.36	3R	1
I	10.99	3R	2
	2 029.1		6
	21.0		6
	19.0		6
	1 979.3		6
	29.7		5
	1 855		5
	1 767		6
	09		6
	1 693		7
	53		6
	1 527		2
	1 499		2
	1 398		2

Nt, *see* Rn

O* (26, 49, 52, 121, 140, 141, 161, 202, 240, 255)

	λ	A
I	13 163	1
I	11 300	2
I	294	2
I	287	4
I	9 263.9	7
I	8 446.77	
I	46.37	
I	7 775.42	6
I	74.20	8
I	71.97	10
I	7 002.22	4
I	6 456.08	9
I	54.55	7
I	53.69	6
I	6 158.21	10
I	56.78	8
I	55.99	7
I	6 046.34	7
I	5 958.53	6
I	50.60	5
I	5 436.83	8
I	35.76	6
I	35.16	5
I	5 330.65	10
I	29.58	7
I	28.97	6
I	5 299.00	5
I	5 146.06	5
I	5 020.13	5
I	19.34	4
I	18.78	3
I	4 968.76	6
I	67.86	5
I	67.40	4
I	4 803.00	4
I	4 773.36	5
I	72.89	4
I	72.54	3
I	4 655.36	4
I	4 368.30	10
I	4 233.32	7
I	22.78	5
I	17.09	4
I	3 947.58	4
I	47.48	7
I	47.29	10
I	3 825.07	6
I	23.56	7
I	3 692.44	7
I	2 883.84	6
I	1 358.7	5
I	55.7	8
I	06.1	10
I	05.0	10
I	02.3	10
I	1 041.7	5
I	41.0	8
I	39.3	8
I	28.2	7

* Spark spectrum is given after arc.

O.—(*Continued*)

	λ	A
I	1 027.5	8
I	25.8	9
I	978.6	4
I	78.0	5
I	76.5	5
I	73.9	4
I	73.3	5
I	71.8	8
I	53.0	2
I	52.4	4
I	50.9	4
I	50.2	4
I	48.7	4
	λ	S
I?	7 952.3	5
I?	50.8	5
I?	47.7	6
	7 157.3	10
	6 654.7	4
	41.3	4
	6 549	5
	6 265	5
	6 115	5
	05	5
	4 943.2	6
	41.0	4
II	24.60	6
II	06.88	5
	4 857.0	4
	4 751.5	4
	05.2	6
	4 699.0	5
	76.246	5
	61.650	5
	50.853	5
	49.148	9
	41.827	8
	38.865	5
	4 596.189	7
	90.983	8
	4 448.3	4
	16.974	9
	14.888	10
	4 366.906	6
	51.275	7
	49.435	7
	47.429	5
	45.570	6
	19.647	6
	17.160	6
	4 254.1	4
	4 189.793	8
	85.453	8
	53.310	6
	32.99	5
	20.267	6
	19.222	8
	05.001	6
	4 097	4
	92.9	4
	89.3	5
	85.2	5
	75.869	10

O.—(*Continued*)

	λ	S
	4 072.156	10
	69.903	9
	3 982.725	6
	73.266	7
	54.368	7
	45.033	5
	11.951	5
	3 882.2	5
	3 759.86	5
	54.72	4
	27.36	5
	12.7	4
	2 881.5	8
	2 631.3	4
	2 528.6	5
	24.1	4
	16.1	7
	14.3	4
	06.8	5
	2 478.5	6
	35.2	6
II	2 182.72	4
II	1 961.60	3tr
	1 787.0	7
	81.4	7
	60.9	8
	43.1	5
	1 277	5
	47.7	10tr
	17.62	10
	00	10tr
	1 175.6	10
	52.6	6
	34.8	10d
	32.3	10
	28.4	5
	1 085.2	10
	66.3	5
	41.71	7
	41.00	8
	39.26	8
	36.9	7
	26.0	5
	10.5	10
	991.5	10d
	90	10d
	78.62	4
	78.00	5
	76.50	5
	73.92	4
	73.26	5
	71.76	8
	17.8	15
	16.4	
	04.7	10
	889.7	8
III	35.288	9
III	35.094	3
II	34.462	10
III	33.741	8
II	33.326	9
III	32.926	7
II	32.756	8

O.—(*Continued*)

	λ	S
II	796.605	6
V	62.004	4
V	61.131	4
V	60.457	5
V	60.232	3
V	59.453	4
V	58.685	4
II	18.567	7
II	18.495	7
III	03.853	7
III	02.898	6
III	02.817	6
III	02.327	6
II	673.752	5
II	72.913	5
II	44.159	6
II	17.064	5
II	16.309	5
	580.975	4
	80.409	3
IV	55.23	5
IV	54.52	
IV	54.07	
IV	53.33	
III	25.79	6
III	08.180	6
III	07.684	5
III	07.384	4
	374.3	4
	05.7	3
	136.6	0

Os (78, 90, 91, 131, 175.1, 232)

λ	A	S
7 852.18	3	
7 602.96	6	
7 407.97	4	
7 253.52	5	
7 148.89	6	
45.50	8	
7 060.62	6	
6 955.96	8	
6 806.61	7	
6 729.54	9	
6 576.81	6	
6 403.18	8	
6 227.74	10	
5 995.99	10	
5 857.57	10	
5 780.81	10	
21.94	10	
5 584.43	10	
23.56	10	
5 416.33	10	
5 149.73	7	
4 865.61	10	
4 794.00	10	3
4 631.83	10	2
16.78	10	2
4 550.40	6	3
4 420.46	10	10
4 394.87	8	3
11.39	10	3
4 293.95	8	3

Os.—(*Continued*)

λ	A	S
4 260.85	10	5
4 175.62	7	2
73.24	9	2
72.55	6	1
35.80	10	5
12.03	10	4
4 091.83	9	2
66.71	10	3
3 977.24	10	3
63.63	10	3
3 876.80	7	3
57.09	10	
49.96	10	
40.29	10	1
36.03	10	2
3 793.90	10	3
90.12	9	3
82.20	10	4
52.7	10	7
20.13	10	2
19.50	10	2
3 670.90	7	2
56.90	7	1
3 598.11	9	2
60.88	9	4
59.82	9	3
28.60	9	3
3 370.60	7	2
01.56	9	2
3 267.94	8	3
32.05	6	3
3 156.25	7	3
3 058.66	7	4
2 909.08	7	5

P (29, 30, 31, 32, 90, 91, 105, 248, 249)

	λ	A	S	G
III	6 043.05			9
III	24.14			8
	5 676.9			5
	5 499.7		3	7
	25.9		7	7
	5 296.1		4	8
	53.5		5	8
	4 943.4		2	7
	4 727.5			6
	4 602.0		5	8
	4 587.9		5	8
	4 479.7		2	5
	4 385.3		2	6
III	4 247.87		7	7
III	23.34		7	7
	4 178.4		5	8
III	4 081.18		7	7
III	60.41		6	6
	3 978.3		6	8
	3 827.4		3	7
	3 706.1		6	7
	3 556.5		2	6
I	3 424.91	1	3	6
IV	3 371.1		5	5
IV	64.4		6	6

P.—(*Continued*)

	λ	A	S	G
IV	3 347.7		6	6
III	3 234.54		6	6
III	20.23		6	
V	3 176.06		5	5
III	2 896.17		5	5
III	84.75		5	
IV	2 739.3		2	5
IV	25.67		4	4
	2 644.2		1	5
I	2 554.95	3	4	1
I	53.31	3	5	
I	35.62	4	5	
I	33.98	2	4	
I	2 154.77	7		7
I	53.63	6		6
I	49.81	8		8
I	36.79	8		8
I	36.10	6		6
I	2 034.02	7		7
I	32.98	6		6
I	24.98	6		6
I	23.98	7		7
I	1 859.36	6		6
I	58.85	8		8
I	51.11	6		6
I	46.8			7
	34.5			4
	1 787.5			6
	82.7			7
	74.8			7
	1 693.8			4
	85.8			5
	71.5			3
V	1 128.039		10	
V	18.015		10	
IV	1 035.54		4	
III	03.64		5	
III	998.03		5	
III	21.86		5	
III	18.69		5	
III	17.14		5	
III	13.99		4	
V	871.420		5	
V	65.475		4	
III	59.69		6	
IV	27.95		6	
IV	24.76		6	
IV	23.21		5	

Pb (46, 59, 62, 74, 75, 90, 91, 133, 150, 154, 172, 223, 276)

λ	A	S
15 315	3	
14 744	3	
13 102	4	
12 564	4	
10 971	3	
888	1	
651	6	
500	10	
291	10	
7 228.98	6	
6 002	5	
5 895.7	5	

Pb.—(*Continued*)

λ	A	S
5 608.8	4	10
5 005.45	3	2
4 386		10
4 245.2		10
42.5		10
4 168.04	3	10
4 062.15	3	10
57.830	5R	10R
19.64	3	10
3 854.0		10
3 739.950	5R	4R
3 683.472	3R	10R
39.584	6R	10R
3 572.739	5R	10
3 176.5		10
37.8		10
3 043.87	1	10
2 873.32	6R	10R
33.07	6R	10R
23.20	4R	10R
02.007	5R	10R
2 663.17	10R	10R
14.203	6R	5R
13.68	3R	3R
2 577.280	6R	3R
2 476.39	4R	2R
46.20	4R	4
43.86	4R	4
11.75	4R	2
01.94	4R	3
2 393.81	5R	3R
32.47	4R	2
2 246.90	6R	4R
37.42	3R	2R
03.5	3	4R
2 175.6	4R	
70.0	6R	2R
59.6	3R	
15.0	5R	
2 088.2	5R	
60	7R	7
59	7R	10
1 869		5
22	8	3
1 796.5	6	3
81		2
26	6	2
1 682.5	6	2
71		2
60		2
1 554		10
34		7
1 434		10
1 349		3
16		10
1 267		7
50		10
32		7
13		3
03		7
1 166		7
1 029		10
04		3

Pb.—(*Continued*)

λ	A	S
954		3
927		7
907		7
894		5
890		3
884		5

Pd (55, 78, 90, 91, 127, 131, 175.1)

λ	A	S
I 8 132.85	6	
I 7 915.89	7	
I 7 763.99	10	
I 7 486.93	7	
I 7 368.14	10	
7 194.11	6	
I 6 916.56	9	
I 6 833.42	8	
I 6 784.6	10	1
I 74.6	6	
I 6 508.4	6	
I 6 130.60	8	
I 5 739.66	4	
I 5 695.08	9	1
I 70.04	10	1
I 5 542.79	10	1
I 5 395.26	10	
5 295.60	10	2
I 5 163.80	10	1
I 4 817.52	9	2
I 4 788.20	8	2
I 4 473.61	7	4
I 4 212.98	6R	10
I 3 958.65	5R	10
I 3 894.21	6R	10
I 32.32	10	10
I 3 799.20	5R	8
I 18.91	4R	10
I 3 690.37	6R	10
I 34.68	10R	10
I 09.55	9R	10
I 3 571.17	5R	10
I 53.09	7R	10
I 16.95	8R	10
I 3 489.78	4R	10
I 81.16	7R	10
I 60.75	7R	10
51.36		10
I 41.41	6R	10
I 33.44	5R	10
I 21.23	8R	10
I 04.59	10R	10
I 3 373.00	6R	10
I 02.14	6R	10
I 3 258.78	6R	8
I 51.64	5R	6
I 42.71	10R	10
I 3 114.05	5R	8
I 3 065.31	4R	4
I 27.92	4R	6
2 980.66	1	10
I 22.51	7R	3
2 854.60	2	10
2 787.94		10

Pd.—(*Continued*)

λ	A	S
2 776.87		10
I 63.09	8R	6
2 658.74	2	10
35.92	2	10
II 28.24	1	10
II 2 565.51	1	10
51.78	1	10
II 05.72	2	10
2 498.79	3	10
88.92	4	10
86.53	1	10
I 76.43	10R	2
I 47.92	10R	8
46.18	1	10
II 33.11	2	10
I 26.87	1	10
18.73	1	10
2 372.16	2	10
II 67.96	1	10
II 1 781.8		6
II 41.0		6
II 04.3		8
II 1 693.4		6
II 67.6		7
II 25.8		5
II 1 596.8		5

Pr (11, 62, 78, 90, 91)

λ	A	S
7 721.82	3	
7 645.68	3	
7 451.72	4	
7 114.58	4	
7 021.55	6	
6 827.70	6	
6 798.69	8	
47.17	6	
6 673.68	10	
56.9	6	
6 566.8	5	
6 478.1	5	
31.9	5	
29.7	5	1
6 359.07	5	
6 281.34	5	
6 161.20	5	2
6 055.13	6	
17.82	5	2
5 939.94	5	2
5 879.18	6	1
23.70	6	1
15.24	8	1
5 707.60	6	
5 668.46	6	
05.63	5	2
5 509.16	4	2
5 469.88	5	
5 381.27	4	2
22.77	5	3
5 220.11	5	3
5 173.92	6	4
10.79	6	3
10.40	6	2

Pr.—(*Continued*)

λ	A	S
4 783.39	4	1
36.72	4	2
4 628.74	4	3
4 563.13	5	3
34.15	6	4
17.58	6	2
10.15	10	10
4 496.43	10	10
68.67	9	8
49.84	8	4
29.23	10	10
08.83	10	10
05.84	8	5
4 368.33	9	8
33.98	10	8
05.80	10	10
4 297.75	8	5
80.09	8	4
72.27	9	5
41.03	10	10
25.34	10	10
23.00	10	10
06.72	10	10
4 189.52	10	10
79.43	10	10
64.19	10	10
43.14	10	10
41.26	10	6
18.49	10	10
00.75	10	10
4 062.83	10	8
56.54	9	8
54.87	9	6
08.73	10	8
3 994.81	10	5
89.70	10	5
82.06	9	6
72.15	8	3
64.82	9	4
47.63	9	4
18.85	7	5
08.43	10	8
08.05	7	4
3 877.22	10	10
16.10	9	8
00.31	5	4
3 762.35	4	1
39.19	4	3
3 687.05	4	3
45.66	3	1
3 355.66	3	1
2 985.77		8
80.51		8
2 488.75		5

Pt (24, 78, 90, 91, 127, 131, 154, 175.1, 266)

λ	A	S
8 224.79	6	
7 217.58	6	
7 113.75	10	
6 842.60	8	
6 710.39	10	
6 523.5	4	

Pt.—(*Continued*)

λ	A	S
6 326.6	10	1
5 840.13	4	1
5 478.50	10	2
75.78	10	2
5 368.99	10	1
01.02	10	5
5 227.64	10	2
5 059.48	10	3
4 684.09	5	1
57.95	6	3
4 552.41	10	10
20.90	10	4
4 498.75	10	10
42.55	10	5
4 327.07	6	3
4 118.69	10	10
3 922.98	8	10
3 672.00	8	3
28.11	10	4
3 485.27	8	3
08.14	8	8
3 301.87	10	5
3 204.05	9	4
00.72	7	3
3 156.56	8	3
39.37	8	3
3 064.71	6R	10
42.62	4R	4
2 997.96	7R	10
29.79	8R	4
2 893.87	6	3
30.29	8R	5
2 794.21	5R	6
71.67	4R	2
33.94	8R	6
19.02	5R	4
05.89	5R	5
02.40	6R	6
2 659.44	10R	10
50.86	4R	4
46.89	6R	4
28.05	7R	5
2 487.18	4R	2
67.44	6R	2
28.05	8R	2
24.90	1	10
2 357.10	4R	2
10.97	3	5
2 288.19	6	3
1 928.5		5
1 889		5
1 723		4
1 680		5
1 597		3
1 473		4
61		4
1 287		5
26		5
13		3
1 199		3
18		3
1 056		3
935		3
930		3

Pt.—(*Continued*)

λ	A	S
805		3
714		3
702		3
696		3
390		1

Ra (90, 91, 242)

λ	A	S
6 446.1	5	8
6 337.0	1	6
6 200.4	5	10
6 167.2	1	8
5 958.2	1	10
II 5 813.7	3	10
5 660.6	5	10
16.6	1	8
01.5		8
5 501.8	1	8
5 406.6	2	8
00.1	2	8
4 971.7	2	8
4 856.1	5	8
I 25.94	10	10
II 4 682.20	10	10
II 4 533.17	10	10
II 4 436.22	5	10
II 4 340.67	10	10
05	3	7
II 3 814.44	10	10
II 3 649.60	10	10
2 813.73	10	10
2 708.94	8	8

Rb (57.1, 78, 90, 91, 134,.174, 201, 205, 223, 228.1)

λ	A	S
I 74 280	3	
72 690	2	
I 65 670	2	
I 64 360	2	
I 52 313	2	
I 46 960	8	
I 190	1	
I 39 898	6	
I 827	3	
I 38 511	3	
I 15 290	10	
I 14 754	10	
I 13 667	10	
I 444	10	
I 237	10	
I 10 082	10	
I 7 947.63	8R	
I 7 800.30	10R	
I 7 408.4	10	
I 7 280.2	10	
6 775.1		9
I 6 298.6	10	3
I 06.5	8	2
I 5 724.5	4	2
5 699.2		6
36.0		6
5 522.8		6

Rb.—(*Continued*)

λ	A	S
5 152.1		6
4 885.6		5
4 782.9		7
76.0		9
4 648.6		10
22.4		10
4 571.8		10
30.3		6
4 430.7		10
26.1		10
01.4		10
4 380.7		10
77.1		10
71.8		10
48.3		10
4 293.9		10
73.1		10
44.4		10
I 15.6	10R	9R
I 01.8	10R	9R
4 193.0		10
36.2		10
04.3		10
4 083.9		10
3 978.1		10
40.6		10
3 801.9		10
3 699.6		10
62.7		10
00.7		10
I 3 591.6	4R	4R
I 87.1	4R	4R
31.6		10
3 492.7		10
61.6		10
34.2		8
3 393.1		7
I 50.9	5R	5R
I 48.7	4R	4R
40.6		8
21.5		8
3 271.0		7
I 29.1	2R	2R
I 28.0	2R	2R
3 198.8		8
11.4		6
3 086.9		5
23.7		5
2 956.1		10
2 807.6		6
2 631.8		6
2 561.9		5

Rh (78, 90, 91, 127, 131, 175.1, 233)

λ	A	S
8 425.51	2	
8 136.20	4	
8 045.40	7	
7 830.05	6	
24.91	10	
7 791.61	9	

Rh.—(*Continued*)

λ	A	S
7 495.22	10	
75.74	10	
7 270.82	10	
7 101.68	10	
6 965.65	10	
6 879.94	10	
6 752.40	10	1
6 630.16	10	
6 519.72	10	
6 414.7	8	1
6 102.72	8	1
5 983.58	8	2
5 831.57	10	1
06.86	10	1
5 686.36	10	1
5 599.43	10	3
44.60	10	1
35.02	10	1
5 424.04	10	2
5 390.43	10	3
79.08	10	3
54.38	10	5
5 193.12	10	3
4 851.62	10	3
4 675.02	10	5
4 528.73	10	5
4 379.93	8	3
74.82	10R	10
4 288.72	10R	8
11.14	10R	10
4 135.29	10R	10
28.90	10R	10
4 097.54	8	4
82.80	10	5
3 958.86	10R	10
34.23	10R	6
3 856.50	10R	10
33.87	10R	10
28.47	10R	10
22.35	10R	10
3 799.31	10R	10
93.22	10R	10
65.08	10R	10
48.22	9	10
00.92	10R	10
3 692.35	10R	10
90.72	10R	10
57.99	10R	10
26.60	10R	10
3 597.15	10R	10
96.19	10R	10
83.10	10R	8
28.03	10R	10
02.53	10R	10
3 478.91	10R	10
74.78	10R	7
70.76	10R	8
62.04	10R	8
34.90	10R	10
3 396.82	10R	10
23.10	10R	10
3 283.56	10R	5
80.54	10R	5
63.14	9	2

Rh.—(*Continued*)

λ	A	S
2 968.67	5	1
2 715.30	2	10
05.62	3	10
2 625.40	2	8
2 520.53	2	10
2 490.76	3	10

Rn* (234, 235, 243, 279)

λ	G
7 057	3
6 309	5
5 977	3
45	2
5 716	6
5 582.4	8
5 393	3
5 084.5	10
4 979.0	10
4 817.5	7
4 797	2
68.8	7?
21.7	5
02	5
4 681.0	10
44.4	10
25.7	10
09.7	7
04.6	9
4 578	8
08	6
4 460	7
35	5
4 371.7	5
49.9	10
08	10
4 203.3	10
4 188	4
66.5	10
14.7	6
4 017.9	7
3 981.8	9
71.8	7
57.3	5
3 867.6	3
3 665	5
12	4

* Radon = (Radium) Emanation = Niton.

Ru (78, 90, 91, 127, 131, 175.1, 233)

λ	A	S
8 710.76	2	
8 264.95	4	
7 924.46	5	
7 881.48	10	
09.18	9	
7 791.87	8	
7 621.52	6	
7 499.78	10	
7 393.92	8	

Ru.—(*Continued*)

λ	A	S
7 238.95	9	
I 7 027.93	10	
6 981.99	10	
23.22	10	
6 824.06	10	
6 690.0	10	
I 6 444.81	9	
I 5 921.45	10	1
I 5 814.99	10	1
I 5 636.24	8	3
5 510.72	10	1
I 5 484.33	10	1
54.82	10	1
27.61	10	1
01.00	10	1
5 361.75	10	1
I 09.26	10	2
I 5 171.03	10	2
I 36.55	10	1
I 4 869.16	10	3
I 15.50	10	3
I 4 757.85	10	3
I 09.48	10	5
I 4 584.45	10	8
I 54.52	10R	10
I 4 460.04	8	8
I 4 372.21	10	10
I 4 297.72	10	10
I 12.08	10	8
I 4 199.91	10R	10
I 12.76	9	5
I 4 080.62	10R	10
3 923.48	8	5
I 3 799.34	10R	10
I 98.89	10R	10
I 90.50	10R	10
I 86.04	10R	10
I 42.28	10R	3
I 30.43	9R	8
I 28.02	10R	8
I 26.93	10R	8
I 3 661.35	8R	10
34.94	10R	3
I 3 596.17	10R	6
I 93.03	10R	6
I 3 498.95	10R	8
I 36.74	10R	5
28.32	10R	3
17.35	10R	3
3 339.55	8	2
I 3 294.13	8	8
3 177.03	3	8
3 064.83	7	2
2 976.58	4	10
65.55	3	10
45.67	3	10
16.26	8	3
2 875.00	7	2
2 734.34	4	10
12.40	4	10
2 692.1	5	10
78.73	4	10
2 402.72	3	10

S (29, 30, 31, 32, 84, 91, 183, 227, 239)

λ	S	G
I 9 237.71		3
I 28.17		2
I 12.80		2
8 694.3		4
8 585.6		6
7 696.7		8
86.1		6
79.6		4
7 244.8		6
I 6 757.2		7
I 48.8		6
I 43.7		5
6 538.1		6
I 6 415.5		4
I 08.1		3
I 03.5		2
I 6 052.8		7
I 46.0		6
I 42.0		5
I 5 706.2		8
I 00.4		7
I 5 696.8		6
60.1		6
47.1		8
40.0		8
14.3		5
06.1		8
5 579.1		6
64.9		8
09.6		10
I 07.0		5
5 473.6		8
53.8		10
32.8		10
28.7		9
5 345.7		8
20.7		8
5 279.0		6
78.6		5
78.1		3
12.6	1	8
01.0		6
5 032.5		8
14.0		8
09.6		6
4 925.3		6
4 696.3		6
95.5		8
94.2		10
4 525.0		6
4 362.5		6
32.7	1	5
4 294.42		8u
84.97	5	8
53.60		10
4 189.9		5
74.31	1	7
63	3	10
53.2		8
45.1	2	10
42.5	2	8
4 028.8		6

S.—(*Continued*)

λ	S	G
3 993.5		5
83.7		5
28.5		8
3 838.29	8	8
37.37	4	7
3 717.7	5	6
3 497.3	8	
IV 3 098.36	5	
VI 933.418	5	
V 854.81	5	
IV 815.97	5	
V 786.51	6	
IV 744.92	5	
IV 48.40	5	
IV 50.23	5	
IV 53.75	6	
IV 661.42	6	

Sa (67, 69, 90, 91, 143, 244)

λ	A	S
8 913.66	2	
8 859.76	2	
8 717.89	3	
8 632.83	3	
8 510.92	4	
8 305.79	4	
8 230.34	3	
8 161.88	3	
8 068.47	4	
7 082.40	5	
39.24	6	
20.47	5	
6 955.33	5	
6 861.14	6	
6 794.20	5	
31.86	6	
6 679.25	5	
01.84	5	
6 569.34	6	2
6 487.65	4	1
26.63	4	1
6 256.69	5	
6 159.49	4	
5 965.70	4	
38.91	4	
5 874.22	4	
14.88	5	
5 787.04	5	
73.77	5	
5 696.74	4	
44.11	6	
26.01	5	
5 550.38	6R	
19.64	5	
5 498.22	6	
93.72	6	
5 341.26	5	
5 271.38	4	1
5 071.20	4	1
44.27	4	1
4 910.41	4	1
4 883.78	4	1
44.20	4	3

Sa.—(*Continued*)

λ	A	S
4 760.28	5	2
04.42	5	3
4 676.92	5	4
15.71	5	4
4 595.31	5	5
43.95	5	5
19.64	8	5
4 467.33	5	10
34.34	6	8
24.35	6	10
4 390.86	5	10
18.95	5	8
4 280.80	5	4
56.40	5	5
29.70	6	4
03.03	6	6
4 118.57	6	5
4 092.29	5	4
3 986.66	4	2
3 745.60	5	3
39.16	6	5
24.91	6	
3 661.36	4	4
34.27	4	4
3 592.62	5	5
3 408.66	3	3
3 365.86	3	3

Sb (13, 59, 74, 78, 90, 91, 138, 154, 257, 276)

λ	A	S
12 118	2	
11 864	4	
268	4	
190	1	
109	2	
082	2	
013	2	
10 880	3	
840	5	
743	5	
678	10	
587	5	
263	4	
080	4	
9 951	2	
9 520	2	
7 924.6	6	
7 844.4	4	
6 806.3	6	1
6 778.4	6	
6 611.4	3	2
6 129.9	6	3
6 079.6	6	1
05.0	6	3
5 730.4	4	
5 639.7	2	5
32.0	4	
5 568.0	3	3
4 693.0		10
4 591.8		5
4 352.2		10
4 265.0		10
4 195.1		8

Sb.—(*Continued*)

	λ	A	S
I	4 033.5	6	4
I	3 722.8	8	5
I	3 637.8	9	6
I	3 504.5	3	10
	3 498.5		10
	73.9		10
I	3 383.2	5	2
I	3 267.5	8R	10
	41.2		10
I	32.5	8R	10
	3 040.7		10
I	29.8	8R	10
	2 913.3		5
I	2 877.920	10R	10R
	51.1	4	4
	2 790.4		10
I	69.95	10R	10R
	27.22	5R	8
	18.90	3R	10
	2 692.27	3R	3
	82.77	4R	5
I	70.67	5R	5
	52.60	3R	8
	12.32	3R	8
I	2 598.076	10R	10R
	90.29		10
I	28.54	6R	10R
	2 478.34	2	6
I	45.55	3R	6
	26.36	3R	3
	2 383.64	3R	4
	73.7	4R	3
I	11.5	6R	10R
	06.5	5R	4
	2 179.25	4R	3R
I	75.9	5R	3R
	2 068.4	4R	1
	54.0		6
	39.7		5
	23.9		4
	1 926.6		5
	1 870.6		10
	67		8
	10		5
	1 783		10
	62		10
	31		5
	25		6
	12		6
	1 585		8
	66.3		8
	14		10
	1 438		10
	1 307		10
	1 225		10
	11		10
	05		10
	1 193		10
	71		10
	68		10
	62		10
	1 048		10
	42		10
	12		10

Sb.—(*Continued*)

λ	A	S
981		10
976		10
861		6
805		5
723		3
691		2
456		1

Sc (78, 90, 91, 96, 123.1, 175.2, 216.1)

	λ	A	S
	8 241.18	4	
	8 194.87	4	
	7 800.44	10	
	7 741.20	10	
	7 697.76	10	
	7 136.13	6	
	6 835.03	10	
	29.52	10	
	19.51	10	
	17.10	10	
	6 737.90	10	
	6 604.62	4	1
	6 413.37	10	
I	6 305.70	10	1
I	6 258.98	10	1
I	10.67	10	1
I	5 711.75	10	1
I	00.15	10	1
I	5 686.86	10	1
I	71.81	10	1
II	57.90	10	2
	5 526.82	10	3
	20.50	10	1
	5 481.98	10	1
	5 349.29	10	1
	5 239.82	10	2
I	5 081.57	10	2
	31.03	10	4
I	4 743.82	10	4
	4 670.41	9	10
II	4 415.56	10	10
II	00.40	10	10
II	4 374.50	10	10
II	25.00	10	10
II	20.73	10	10
II	14.10	10	10
II	4 246.84	10	10
	4 165.21	6	
I	4 082.42	10	3
I	54.55	8	3
I	47.82	7	2
I	23.70	10	8
I	20.41	10	8
I	3 996.61	10	2
I	11.81	10	6
I	07.50	10	6
II	3 651.81	10	10
II	45.32	10	10
II	42.80	10	10
II	30.76	10	10
II	13.83	10	10

Sc.—(*Continued*)

	λ	A	S
II	3 590.50	10	10
II	89.65	10	10
II	80.96	10	10
II	76.36	10	10
II	72.55	10	10
II	67.71	10	10
II	58.55	10	10
	35.73	10	10
II	3 372.15	10	10
II	68.95	10	10
II	61.95	10	8
II	61.29	10	8
II	59.69	10	8
	53.74	10	10
I	3 273.64	5	2
I	69.92	5	2
	3 065.1	10	5
	52.92	10	4
	45.73	10	3
	39.94	10	2
I	19.33	10	1
	2 988.95	10	3
	2 734.10	4	8
	2 699.12	6	10
II	2 560.26	5	6
II	52.39	10	10
	2 438.62	5	
	2 272.9	4	
	2 062		4
	1 993		5
	1 880		5
	1 603		5
	1 214		6
	791		5

Se (80, 169, 189)

	λ	G	S	A
I	7 061.9	5		
I	6 831.0	5		
I	6 746.4	6		
I	6 699.6	6		
I	79.5	5		
I	6 325.6	6		
I	5 961.9	5		
	5 866.2	6		
	42.6	6		
I	5 753.3	7		
	47.6	7		
I	18.1	7		
	5 697.9	8		
	23.1	9		
I	17.8	5		
	5 591.2	8		
	67.0	9		
	22.6	8		
	5 455.8	7		
I	5 374.1	10		
I	69.9	10		
I	65.4	8		
	05.3	9		
	5 271.1	8		
	53.7	7		
	27.5	9	2	

Se.—(*Continued*)

	λ	G	S	A
	5 176.0	9	2	
	42.1	8	1	
	5 096.5	8	1	
	68.6	8	1	
	31.3	8		
	4 992.9	8	1	
	75.7	8		
	4 844.8	10	1	
	40.5	8	1	
	4 763.6	8	2	
I	42.4	8		
I	39.1	9		
I	30.9	10		
	4 648.4	8	5	
	18.7	8	3	
	04.3	9	5	
	4 563.9	9	4	
	16.2	8	2	
	4 467.6	9	3	
	49.2	8	2	
	46.0	8		
	01.0	9	3	
	4 382.8	10	6	
	20.4	9	3	
	4 280.3	8	2	
	4 182	9	10	
	76	9	10	
	69.0	10	3	
	08.8	8	3	
	4 083.2	8	3	
	46.7	10	3	
	08.1	8	2	
	3 901.6	8		
	3 877.3	8	4	
	49.6	8	2	
	00.9	10	8	
	3 738.7	10	10	
	11.6	10	6	
	3 637.5	10	10	
	3 544	10	10	
	14	10	8	
	3 387.2	10	6	
	79.8	8	3	
	23.1	8	3	
	3 225.9	8	3	
	3 185.5	9	3	
	3 094.3	8	3	
	69.9	8	2	
	60.8	10		
	38.7	8	2	
	2 951.7	10	3	
	14.9	9	3	
	2 880.4	8	3	
	37.2	8	4	
	2 777.7	9	3	
	67.4	10	3	
	2 685.9	8	4	
	30.9	8	5	
	2 591.4	10	5	
	2 459.5	7	3	
	2 354.3	5	3	
	2 073		3	8
	63		8	8
	38		8	2

Se.—(*Continued*)

λ	G	S	A
1 993			5
60		10R	10
1 854		7	

Si (73, 79, 90, 91, 94, 154, 160, 161, 168, 217)

λ	A	S	G
II 6 371.359		2	8
II 47.091		5	10
II 5 978.970			7
II 57.612			5
III 5 739.762			8
I 08.400			5
II 5 056.020		2	10
II 41.063		1	8
III 4 574.777		1	4
III 67.872		2	7
III 52.654		3	9
II 4 130.884		6	10
II 28.053		5	8
IV 4 088.863		6	10
I 3 905.515	10	5	10
II 3 862.592		4	6
II 56.021		5	8
II 53.657		3	3
III 06.56		3	5
III 3 796.11		7	4
III 91.41		6	3
III 3 590.46		2	8
IV 3 165.72			8
IV 49.56			6
III 3 093.423			6
III 86.225			7
I 2 987.647	5	4	
I 2 881.587	10R	10	
I 2 631.28	5	6	
III 2 541.83		10	
I 28.516	10R	8	
I 24.118	10R	8	
I 19.212	8R	5	
I 16.119	10R	10	
I 14.322	8R	5	
I 06.904	10R	6	
I 2 435.159	5R	5	
IV 2 287.08		10	
I 16.685	3	3	
I 2 124.140		6R	
II 2 072.61			10
II 71.94			8
I 58.20			5R
I 1 988.97		5	
1 885		10	
II 17.06			10
II 08.14			8
II 1 711.0			6
II 1 533.55			10
II 26.38			8
III 00.39			5
IV 1 402.9			8
IV 1 393.9			10
II 1 265.04			10
II 60.66			8
III 06.9			10

Si.—(*Continued*)

λ	A	S	G
II 1 194.89			5
III 10.47			5
IV 1 066.3			8
IV 818.0			7
IV 815.0			7
IV 749.7			3
IV 457.7			3
IV 361.6			1

Sm, *see* Sa

Sn (4, 46, 59, 90, 91, 138, 154, 167, 171, 223, 251, 276, 291)

λ	A	S
13 022	2	
12 983	5	
11 934	10	
853	4	
827	4	
740	9	
672	2	
618	6	
457	6	
279	10	
194	7	
10 896	4	
808	1	
458	1	
9 852	1	
8 552.6	7	
8 114.1	7	
6 844.2	2	2
6 579.2		4
6 453.5	3	6
6 310.8	4	
6 171.5	4	
54.6	5	
49.6	6	
6 069.0	7	
54.9	5	
37.7	5	
5 970.3	5	
5 799.4		10
31.70	7	3
5 589.4		10
62.7		10
5 333		10
4 585.6		10
24.74	6	10
3 801.03	9R	8R
3 352.3		10
30.60	6R	6
3 283.5		10
62.33	10R	5R
3 175.047	10R	9R
3 034.116	9R	8R
32.78	3R	3
09.135	9R	8R
2 913.54	6R	4
2 863.322	8R	8R
50.61	6R	7R
39.987	8R	10R
13.58	5R	4R

Sn.—(*Continued*)

λ	A	S
2 785.02	3R	4
79.81	4R	5
06.50	7R	7R
2 661.25	5R	4R
58.61		10
2 594.43	4R	3R
71.60	5R	5R
46.56	5R	5R
2 495.72	5R	4R
83.40	5R	4R
29.505	7R	8R
21.699	6R	8R
08.18	4R	3
2 354.84	5R	6R
34.80	4R	4R
17.22	5R	4R
2 286.68	4R	3R
68.92	3R	3R
46.05	3R	3R
31.73	4R	2
09.63	3R	2R
2 199.3	3R	2R
94.5	3R	2R
71.3	3R	
51.4	3R	2
48.6	3R	1
40.6	3R	1
21.2	3R	
13.9	4R	1R
00.8	4R	
2 096.3	4R	
91.6	3R	1
72.9	5R	
40	4R	
1 983.4	3R	
51.4	3R	
1 899	3	10
11		10
1 757		10
1 570		4
1 475		6
37.7		10
10.8		5
1 387.0		5
70		4
47		4
27		7
14.7		10
1 251		20
24		10
1 158		20
32		12
1 089		5
86		5
62		3
58		3
44		15
19		15
956		10
910		3
907		3
902		15
892		3

Sn.—(*Continued*)

λ	A	S
784		3
752		3
508		2
502		2
410		2
392		1

Sr (59, 61, 74, 75, 78, 90, 91, 110, 158, 174, 223, 253)

λ	A	S
I 30 665		
482		
I 110	5	
I 29 225	6	
28 964		
516		
I 27 356	6	
26 947		
I 915	6	
806		
714		
I 024	6	
20 767		
705		
I 262	10	
17 446		
170		
137		
I 11 242	10	
II 10 915	10	
II 328	10	
II 038	10	
7 673.10	6	
I 21.53	5	
I 7 309.45	7	
I 7 232.24	5	
I 7 167.30	6	
I 7 070.15	10R	1
I 6 878.37	10	
I 6 791.07	6	1
6 643.55	5	2
17.27	6	3
6 550.27	6	3
46.80	5	2
04.01	8	4
6 408.48	9	4
I 6 388.27	6	1
I 86.53	7	1
I 80.74	5	1
I 69.98	4	1
I 63.95	4	1
5 598.4	6	1
I 43.32	5	2
I 40.04	5	2
I 34.80	5	2
I 21.76	6	3
I 04.19	5	3
I 5 486.13	5	2
I 80.87	7	4
5 256.91	6	3
38.56	6	1
29.28	5	1
25.12	5	1
22.21	5	1

Sr.—(*Continued*)

	λ	A	S
I	5 156.08	5	1
I	4 967.92	4	1
I	62.25	6R	2
I	4 892.01	6	2
I	76.31	6	1
I	76.07	6	1
I	72.48	6	2
I	55.07	4	1
I	32.07	6	3
I	11.86	6R	4
I	4 741.91	5	1
I	22.27	6	3
I	4 607.342	10R	6R
I	4 438.04	6	3
I	4 361.71	4	2
II	05.47	4	4
II	4 215.515	9R	9R
II	4 161.81	4	3
II	4 077.714	10R	10R
I	30.38	5	4
I	3 940.80	5	2
II	3 464.47	6	7
II	3 380.72	5	6
I	66.33	5	2
I	51.26	6R	2
	30.01	4	2
I	22.23	5	1
I	07.54	4	1
I	01.74	5	2
I	2 569.50	3R	
I	2 428.11	3R	
I	2 354.3	1R	
II	2 166	1R	1
II	1 778	9	
II	69	8	
II	1 620	5	
II	1 613	4	

Ta (75, 78, 90, 91, 126, 196)

λ	A	S
6 966.16	2	
6 866.20	3	1
6 675.51	5	2
73.70	4	1
6 516.11	10	3
14.36	9	3
6 485.36	10	10
50.36	10	5
30.76	9	5
6 389.42	8	3
09.56	8	3
6 268.66	8	2
56.62	8	2
6 045.4	5	
5 997.24	7	
5 882.29	5	
11.09	8	
5 776.71	7	2
5 664.88	6	3
5 518.89	3	2
5 461.29	4	2
5 136.47	3	3

Ta.—(*Continued*)

λ	A	S
4 936.40	3	1
4 812.74	4	2
4 740.14	4	2
4 691.89	3	2
81.87	5	5
4 574.32	5	3
30.82	5	3
10.98	8	3
4 415.73	3	3
4 279.06	3	2
05.88	6	2
4 175.22	4	3
29.42	5	2
4 067.91	6	2
26.95	4	2
3 918.51	3	2
3 642.05	10	2
26.61	9	3
07.40	7	2
3 566.72	4	1
11.03	8	2
3 497.85	5	
36.00	5	1
06.94	5	2
3 361.63	5	1
17.91	7	1
11.14	9	3
3 242.05	4	
23.83	4	2
3 170.28	4	1
24.96	4	1
03.25	5	1
3 049.54	5	1
12.53	5	3
2 965.15	4	4
33.56	5	2
2 891.85	4	1
02.07	3	1
2 758.31	3	1
14.67	3	2
2 647.46	3	2

Tb (71, 90, 91)

λ	A	S
6 896.37	5	
6 794.58	5	
85.12	4	
6 677.94	6	
6 331.68	4	
6 038.97	4	
5 967.35	5	
5 851.07	5	
03.11	5	
5 785.18	5	
47.58	6	
5 685.72	5	
5 524.11	5	
5 470.34	5	
24.10	5	
5 375.98	5	
69.71	5	
54.87	5	
19.23	5	

Tb.—(*Continued*)

λ	A	S
5 228.11	5	
5 089.11	5	1
65.79	5	
4 993.85	6	
70.99	5	
31.79	6	
15.91	6	
4 881.14	6	2
75.58	6	1
37.58	6	1
13.77	6	
4 752.50	10	8
47.79	6	
39.92	6	1
34.19	6	1
16.08	6	
02.40	8	2
4 681.86	8	
62.79	6	1
45.29	9	2
41.98	8	3
4 578.68	8	3
63.69	6	1
11.52	6	
4 493.08	5	2
36.13	5	
23.11	5	1
4 367.31	5	3
56.84	6	2
53.20	6	3
42.53	6	2
18.85	6	3
13.25	6	1
4 278.54	10	10
4 187.16	5	
44.46	5	10
4 094.44	5	4
66.22	5	3
61.59	6	2
33.07	8	8
12.85	7	5
05.57	8	10
3 981.90	10	10
76.86	10	10
39.54	10	10
25.45	10	10
3 899.19	8	8
74.19	10	10
48.76	10	10
3 776.50	8	8
65.14	6	8
11.75	10	4
03.93	8	8
02.85	6	10
3 676.35	8	10
58.87	8	8
50.42	7	8
38.45	7	5
28.20	8	3
3 568.52	7	5
61.75	10	10
09.18	10	10
3 454.06	7	4

Tb.—(*Continued*)

λ	A	S
3 413.77	5	4
3 324.40	8	5
3 293.08	5	8
74.24	6	
18.95	5	5
3 139.65	4	3
3 078.87	4	8
2 913.28		10
09.24		10
2 891.29		10
2 658.91		10
2 539.91		8

Te (75, 90, 91, 154, 270)

λ	A	S
6 438.0		10
5 755.8		8
08.1		10
5 649.3		10
5 449.7		5
5 045.2		4
4 866.5		4
3 175.13	9	2
2 769.65	9	4
2 530.73	7	5
2 385.78	10R	10R
83.27	10R	10R
2 265.52	5R	3
59.02	8R	3
55.50	5R	3
08.88	6	2
2 160.12	6	1
47.33	8	1
43.0	9R	1
2 081.8	8	
1 826		5
1 461		7
1 345		7
1 297		5
91		5
23		7
19		7
16		7
1 174		7
67		10
50		5
23		7
17		5
07		5
1 064		5
07		5
04		5
931		4
928		4
813		5
634		1
509		1

Th (78, 90, 91, 157)

λ	A	S
7 054.8	4	
6 993.1	4	
89.7	4	
6 584.0	4	

Th.—(*Continued*)

λ	A	S
6 531.3	4	
6 462.64	5	1
57.26	4	
16.10	4	
11.91	4	
6 396.4	4	
76.94	4	
58.64	4	
42.86	4	
6 274.14	4	1
61.06	4	1
6 120.56	4	1
12.84	4	1
04.79	4	1
6 099.08	4	1
87.28	5	1
15.41	4	1
5 989.02	7	2
14.38	4	1
5 870.51	4	1
15.38	4	
5 749.32	4	1
07.07	4	1
5 639.71	5	1
04.48	4	1
5 539.89	5	2
5 462.58	4	1
35.86	4	1
5 325.10	4	2
5 277.45	5	2
47.65	5	2
5 148.17	4	2
5 067.97	5	
49.77	7	3
28.59	5	2
17.24	8	3
4 987.16	5	3
64.15	5	1
19.80	9	6
4 863.17	9	8
32.78	5	2
18.62	4	4
4 774.27	5	2
61.10	5	3
52.41	6	4
40.47	6	4
4 619.50	7	3
02.88	5	1
4 510.54	4	5
4 391.12	5	10
81.89	5	10
4 208.85	4	8
4 178.04	3	5
16.75	2	6
4 085.05	3	7
69.23	3	7
19.14	5	10
3 752.58	4	6
41.21	5	6
3 659.51	3	6
27.40		2R
17.07	4	5
01.05	3	7

Th.—(*Continued*)

λ	A	S
3 538.75	1	10
11.64	5	6
07.57		10
3 469.94	4	5
3 392.05	4	5
13.69	1	10
00.54	1	10
3 290.59		10
32.08	1	7
21.27	2	10
16.58		8
3 188.22	5	5
08.26	4	5
3 097.92		6
2 978.68		8
2 898.92		6
2 686.17		6
2 512.72		8
2 463.72		7
41.30		9
31.74		7
27.98		8
13.50		6

Ti (9, 37, 38, 75, 78, 88, 90, 91, 92, 146, 154)

λ	A	S
I 8 518.2	4	
I 8 435.6	5	
I 26.5	4	
I 7 251.7	6	
I 44.86	5	
I 09.45	8	
I 6 861.47	5	1
I 6 743.15	5	3
I 6 556.09	6	5
I 6 303.77	6	3
I 6 261.10	9	9
I 58.72	9	9
I 58.11	9	9
I 15.26	7	10
I 6 126.22	9	5
I 6 091.18	7	5
I 85.24	7	4
I 5 999.666	6	2
I 78.535	8	8
I 65.821	8	10
I 53.155	8	10
I 41.748	7	4
I 22.103	7	4
I 18.542	6	3
I 5 899.290	9	10
I 66.435	9	10
I 5 766.33	7	3
I 62.276	7	2
I 15.124	8	2
I 08.231	5	1
I 02.683	6	2
I 5 689.475	8	3
I 75.427	7	4
I 62.92	7	3
I 62.164	7	8
I 44.137	7	10

Ti.—(*Continued*)

λ	A	S
I 5 565.470	7	8
I 14.540	8	8
I 14.349	7	8
I 12.531	8	10
I 5 488.228	6	3
I 77.727	9	4
II 5 336.80	3	10
I 5 297.248	7	3
I 83.449	7	3
II 26.554	3	10
I 10.391	8R	9
I 5 192.970	8R	10
II 88.692	4	10
I 73.743	7R	7
I 5 064.66	10	5
I 39.960	9	3
I 38.407	9	8
I 36.471	9	8
I 35.912	7	9
I 25.582	8	3
I 24.850	9	3
I 22.870	9	5
I 20.027	8	5
I 14.25	10	9
I 07.214	9	10
I 4 999.511	10	10
I 91.07	9	10
I 81.73	9	10
I 4 885.088	8	5
I 70.138	7	3
I 40.882	9	4
I 20.417	7	3
I 4 759.281	8	6
I 58.131	8	5
I 31.172	5R	3
I 4 698.769	8	3
I 91.339	8	4
I 81.912	9	6
I 67.592	10	5
I 56.461	8	3
I 23.106	9	3
II 4 571.98	6	10
II 63.767	4	10
I 55.494	9	3
II 49.63	5	10
I 48.772	9	3
I 44.696	9	3
I 36.053	6R	4
I 35.921	6R	
I 35.576	8R	3
I 34.781	9R	4
I 33.249	10R	5
I 27.316	10	4
I 22.809	9	4
I 18.030	9	4
I 12.74	10	4
II 01.28	5	10
II 4 468.50	6	10
I 57.439	9	5
I 55.33	10	4
II 43.808	6	10
I 27.106	8	4
II 4 395.044	7	10

Ti.—(*Continued*)

λ	A	S
II 4 337.924	5	10
I 14.807	7	3
II 07.89		8
I 05.915	10	8
I 01.084	10	3
I 00.555	10	2
II 00.058	6	8
I 4 298.675	10	4
II 94.108	6	10
I 90.94	8	2
II 90.230	4	10
I 89.083	10	4
I 87.417	9	4
I 82.714	6	3
I 74.59	10	4
II 4 171.92	3	10
II 63.656	4	10
I 4 078.478	6	4
I 24.578	7	3
I 09.662	7	4
I 3 998.643	10	6
I 89.764	10	6
I 64.274	7	3
I 62.859	7	3
I 58.212	10	5
I 56.343	10	4
I 48.679	10	4
I 47.774	8	3
II 13.47	5	10
II 00.544	5	10
I 3 882.88	9	3
II 3 761.327	8	10
II 59.298	9	10
I 52.866	10	5
II 41.646	3	10
I 41.065	10	2
I 29.812	8R	4
II 06.22	2	8
II 3 685.190	10R	10
II 62.24	4	10
II 59.77	4	10
I 53.497	10R	4
I 42.680	10R	3
II 41.335	4	10
I 35.467	9R	3
II 3 535.41	4	10
II 20.26	3	8
II 10.846	8	10
II 04.89	7	10
II 3 477.188	9	10
II 61.504	9	10
II 56.392	2	9
II 52.476	1	8
II 44.318	4	10
II 3 394.58	2	10
II 87.835	8	10
I 85.949	8R	
II 83.765	8R	10
II 80.285	7	10
II 72.80	10	10R
I 71.456	9R	2
I 70.438	9R	2
II 61.215	8R	10R

Ti.—(*Continued*)

	λ	A	S
I	3 354.641	8	3
II	49.408	9R	10R
II	49.039	6R	8R
I	41.874	6R	10R
II	35.192	7	10
II	32.108	5	8
II	29.458	6R	10
II	22.940	8R	10
II	3 261.601	4	10
II	48.604	4	10
II	41.989	7	10
II	39.042	7R	6R
II	36.579	7R	6R
II	34.521	8R	10R
II	24.24	5	8
II	22.84	7	8
II	17.061	8	8
II	02.540	6	10
I	3 199.924	9R	3
I	92.002	9R	1
II	90.877	7	10
I	86.462	9R	3
II	68.522	9	10
II	62.572	9	6
II	3 088.032	10	10R
II	78.646	9	6
II	75.232	9	4
II	72.971	8	3
II	72.106	8	3
III	2 984.8		10
I	67.220	8	2
I	56.132	10	2
I	48.250	9	2
I, II	41.991	9	4
I	12.092	8	2
II	2 884.102	7	8
II	41.935	8	4
II	28.067	3	8
II	17.84		10
II	10.302	4	10
II	05.0		10
I	2 758.074	6	1
II	51.7		8
I, II	42.328	7	4
I	2 669.598	6	2
I	61.966	5	
I	46.638	9	2
I	44.263	9	3
I	41.09	9	2
I	19.940	5	1
I	11.28	7R	1
I	2 599.914	6	2
III	63.4		10
III	40.0		10
III	27.8		10
II	25.616	4	10
III	16.0		10
I	2 418.363	3	1
	14.0		10
I	2 384.527	3	1
III	75.0		6
III	46.8		6
	2 074.6		2

Ti.—(*Continued*)

	λ	A	S
IV	2 068.3		2
	1 671.2		10
	58.7		10
	1 437.3		5
III	1 298.8		2
III	94.3		2
	64.6		5
	1 120.5		5
	13.4		5
	834.0?		2
	781.6		10
	324		1

Tl (46, 59, 62, 74, 75, 87, 90, 91, 137, 154, 167, 170, 203, 205, 251)

	λ	A	S
I	71 170	1	
I	70 230	1	
I	55 590	1	
I	51 058	2	
	39 286	6	
I	246	2	
I	215	2	
I	38 131	5	
I	35 950	2	
I	680	1	
I	33 393	1	
I	27 889	4	
	024	1	
I	21 803	3	
	397	1	
	20 486	1	
I	16 340	10	
I	123	10	
I	14 598	3	
I	593	1	
I	515	10	
I	13 014	10	
I	12 736	10	
	728	2	
I	492	2	
	11 691	1	
I	594	8	
I	513	10	
I	482	5	
I	10 496	8	
I	492	5	
I	292	6	
I	9 513	3	
I	9 171	2	
I	36	2	
I	8 376	1	
	6 714	5	2
I	6 550	8	3
	5 948.9	8	8
I	5 350.47	10R	10
	5 153.3		10
	4 738.1		10
I	3 775.73	10R	10R
I	3 529.41	8R	10
I	19.22	10R	10R
I	3 229.76	10R	1
I	2 921.53	6R	1

Tl.—(*Continued*)

	λ	A	S
I	2 918.34	10R	1
I	2 826.2	8R	
I	2 767.89	10R	10
I	10.7	4R	4
I	09.24	8R	6R
I	2 609.75	4R	
I	08.98	6R	2
I	2 585.6	4R	1
I	80.16	8R	6R
I	52.9	2R	
I	52.5	6R	
I	17.44	4R	
I	2 379.60	8R	10R
I	16.0	6R	4
I	2 237.8	6R	3R
I	07.1	4R	2
	1 893		10
	28		6
	15		10
	1 793		9
	1 660		10
	1 561		8
III	59		10
	1 492		4
	78		4
	1 337		4
III	1 266		8
	1 082		4
	29		4
	908		2
	817		3
	697		4
	662		3
	395		1

Tu* (65, 91)

λ	A	S
7 731.52	4	
7 481.08	5	
6 845.99	8	
44.30	8	
6 779.77	8	
6 657.72	5	
04.95	8	
6 460.26	10	
5 975.01	5	
5 895.63	6	
38.73	5	
5 764.29	5	
5 631.39	6	
4 675.27	5	
4 582.35	6	
22.55	5	10
19.56	6	1
4 359.93	8	5
4 242.15	10	8
06.01	3R	1
4 187.61	10R	5
4 094.18	10R	5
52.21	8	3
3 958.08	6	3
49.27	5	1

* Thulium = Neothulium.

Tu.—(*Continued*)

λ	A	S
3 916.50	7	2
00.83	6	2
3 847.99	10	10
38.20	6	4
3 761.91	8	7
61.33	8	7
51.82	5	2
25.07	5	3
17.91	10R	4
04.83	5	2
01.37	9	9
00.27	10	9
3 694.75	5	2
78.89	5	3
78.18	5	2
68.08	6	3
65.79	5	3
53.62	5	3
08.77	9	4
3 566.47	5	3
65.90	5	8
36.57	5	2
36.20	5	3
35.53	5	3
17.62	4	
3 462.21	10	10
53.68	10	5
41.53	7	6
29.97	5	4
25.12	7	7
3 397.50	6	4
62.63	7	7
02.47	5	3
3 283.40	5	4
3 172.82	9	10
57.34	6	6
51.03	7	9
33.87	9	9
31.26	10	10
3 042.36	4	2
2 640.75	5	1
2 509.10	3	2
2 480.18	3	

U (78, 90, 91, 117, 146, 154, 181)

λ	A	S
8 691.26	3	
07.92	5	
8 540.17	3	
04.66	4	
8 496.10	3	
50.04	4	
45.38	4	
8 381.93	3	
18.4	3	
8 262.09	4	
23.08	4	
7 970.44	3	
7 881.91	4	
7 784.11	5	

U.—(*Continued*)

λ	A	S
7 631.72	3	
19.34	3	
7 533.91	5	
7 425.49	3	
7 128.88	4	
01.61	3	
7 074.78	4	
6 826.90	4	
6 465.00	4	
49.19	10	1
6 395.46	6	
72.46	5	
6 171.88	4	
6 077.28	4	
51.74	4	1
5 997.32	4	
76.32	5	
15.39	8	1
5 837.7	4	1
5 798.54	4	1
80.56	4	
58.18	6	
23.63	5	1
5 669.45	4	
21.50	4	1
10.88	5	1
5 564.16	5	1
27.84	10	4
5 492.94	8	4
81.20	5	3
75.71	5	3
5 280.38	4	1
5 027.38	5	4
4 899.27	4	2
19.48	4	2
4 772.70	4	3
56.79	5	2
31.60	5	3
4 689.07	5	4
46.60	4	4
27.08	5	5
4 543.64	5	8
4 472.34	5	6
4 393.60	5	2
41.67	5	4
4 287.87	4	3
41.68	5	4
4 171.61	5	3
63.70	5	2
56.65	5	2
4 090.13	6	4
3 985.80	5	2
32.04	5	3
3 859.57	5	3
31.45	4	3
3 670.07	4	3
3 566.61	4	2
2 008		5
1 985		5
81		5
1 833		5
1 587		5
764		5
397		1

V (37, 62, 78, 90, 91, 146, 154, 159)

λ	A	S
8 919.8	3	
8 255.8	4	
53.5	4	
41.6	4	
03.0	4	
I 8 161.03	4	
I 16.76	5	
7 338.90	4	
6 753.03	4	
I 6 531.43	10	6
I 04.18	4	4
I 6 452.38	4	
6 326.87	5	4
I 6 296.53	10	6
I 92.83	9	7
I 85.18	9	7
I 74.67	5	8
I 68.85	5	5
I 51.83	9	8
I 43.10	9	4
I 42.85	4	10
I 30.78	10	9
I 16.35	8	10
6 199.20	8	8
I 19.54	10R	8
I 11.67	10	9
I 6 090.24	10R	10
I 81.47	10	6
I 39.74	10	10
I 5 737.07	7	7
31.28	8	5
I 27.04	10R	10
I 07.02	8R	9
I 03.61	10R	10
I 5 698.53	10R	10
70.87	9	8
I 27.66	8	9
5 507.75	5	8
5 487.9	5	8
15.28	10	8
01.95	7	8
5 194.85	4	8
38.44	6	10
28.54	8	9
I 4 881.57	10R	10
I 75.48	10R	10
I 64.75	10R	9
I 51.50	9	8
I 07.56	10	8
I 4 796.94	7	8
I 86.52	6	8
76.48	6	9
I 4 619.68	8	9
I 4 594.10	10R	10
I 86.367	8	9
I 80.402	8	9
I 77.17	8	8
71.79	6	10
60.72	7	9
49.65	6	8
45.40	9	8
4 488.90	8	10
69.71	8	8

V.—(*Continued*)

λ	A	S
4 462.367	9	9
I 60.31	10R	10R
52.03	8	10
I 44.22	8	8
I 41.686	7	8
I 37.841	8	6
I 21.586	8	5
16.61		10
I 08.516	6R	10R
I 08.209	6R	1
I 07.65	8R	4R
I 06.65	8R	5R
I 00.588	9	10
I 4 395.24	10	10
I 89.987	10R	10R
I 84.73	10R	10R
I 79.240	10R	10R
I 52.88	10	6
I 41.01	9	10
I 32.830	8	10
I 30.031	6	10
4 284.06	7	10
76.96	6	8
71.56	6	8
68.64	8	8
I 09.85	6	8
05.08	2	10
02.44	1	8
4 183.4	2	10
I 34.47	9	10
I 32.00	10R	10
I 28.074	10	10
I 16.70	10R	7
I 16.479	8	7
I 15.180	10	2
I 05.166	10	4
I 4 099.796	10	2
I 92.692	10	3
I 90.59	10	10
35.62	2	10
23.38	2	10
05.71	3	10
3 998.73	8	4
97.13	3	8
90.57	10	6
73.64	3	10
51.96	3	10
16.40	2	8
14.31	2	8
I 09.88	6R	
02.258	8R	2
3 878.73	1	10
I 75.081	8R	2
I 64.861	8	3
I 55.852	9R	3
47.32	4	10
I 18.241	8	3
15.51	3	10
I 13.495	8	3
3 794.96	8	3
87.15	2	8
70.97	3	10
45.80	3	10
32.75	5	10

V.—(*Continued*)

λ	A	S
3 727.46		10
15.47	6	10
I 03.566	8	3
00.34	1	8
3 695.867	8	3
I 92.22	8	4
I 90.29	8	4
I 88.070	8	3
69.42	1	8
67.72	8	3
18.95	1	8
3 593.33	5	10
92.02	5	10
89.75	5	10
66.17	3	8
56.80	4	10
45.20	6	10
30.77	6	10
24.73	3	8
17.30	5	10
04.44	4	10
3 496.94	3	8
57.13	2	10
3 337.9		8
3 279.84	3	10
76.12	10	10R
71.11	10	10R
67.706	10	10R
54.75	2	8
37.87	6	10
17.11	6	10
I 02.38	5R	2
3 198.098	5R	2
90.67	7	10R
88.51	5	8R
87.70	5	8R
I 85.406	10R	2R
I 83.99	10R	2R
I 83.415	10R	2R
39.73	1	8
36.51	2	8
34.93	2	8
II 30.270	5	10R
II 26.21	6	4R
II 25.288	8	2
II 18.383	10R	10R
II 10.71	8	10R
II 02.303	10	10R
II 3 093.14	4	10R
66.37	4R	1R
60.45	3R	
56.35	3R	2
50.88	3R	3
44.93	4R	1
01.20	3	8R
2 989.59	1	3R
77.55	8	1
76.53	8	3
76.21	8	2
74.24	8	1
68.38	8	10R
II 57.52	8	6
55.80	8	
II 52.08	8	8R

V.—(*Continued*)

	λ	A	S
II	2 944.6	2	8R
	43.20	8	1
	42.35	10R	2
II	41.43	3	10R
II	30.813	8	5R
II	24.650	8	8R
II	24.021	8	8R
	23.626	8R	
II	20.383	8	3
	19.99	8	2
	14.925	10	2
II	11.055	6	3R
	10.385	8	4R
	10.021	8	4R
	08.811	8R	8R
II	07.47	8	3R
	06.13	8	4R
	04.130	8	1
	2 893.321	10	5R
	92.67	10	5R
	92.46	10	
	91.65	10	6R
	84.79	6	10
	82.51	6	8
	10.238	2	8
	2 762.6		2R
	15.69	10	5
	06.19	8	3R
	00.962	8	5R
	2 687.99	10	5R
	79.35	8	4
	78.600	7	3
	77.830	7	4
	2 074.5		15
	1 454		2
	37.3		2
	1 112		2
	723		3
	684.5?		5
	483.0		5

W (10, 24, 75, 78, 90, 91, 116, 146)

λ	A	S
8 613.22	3	
8 594.38	3	
85.07	3	
8 123.78	3	
7 940.92	3	
7 784.11	3	
7 688.93	3	
14.07	3	
7 569.87	3	
7 483.34	3	
7 385.08	3	
7 296.57	3	
7 140.51	3	
6 984.29	4	
34.28	4	
6 820.7	4	

W.—(*Continued*)

λ	A	S
6 693.12	5	
6 538.15	4	
6 445.15	4	2
04.22	4	2
6 292.05	4	2
6 012.80	4	3
5 947.58	4	2
5 804.86	7	5
5 735.10	8	8
5 648.39	7	10
5 514.72	10	10
5 492.34	10	10
5 224.68	10	10
5 071.74	5	10
53.30	10	2
15.34	8	8
06.17	8	10
4 843.829	9	5
4 680.52	8	5
4 588.74	7	3
70.66	7	3
4 484.20	8	4
4 302.12	8	5
4 294.62	6R	9
15.38	3	8
4 074.37	7	6
08.76	10	10
3 867.98	5	5
3 736.24	1	10
3 641.41	4	10
17.52	8R	2
13.79	3	10
3 592.42	3	10
72.47	3	10
45.23	6	3
08.74	6	5
3 401.90	1	8
3 376.14	1	10
3 077.50	1	10
49.68	6R	1
46.44	5R	1
41.86	5R	1
17.44	6R	2
2 946.98	8R	3
44.41	7R	3
34.99	5R	3
2 896.44	6R	3
96.01	4R	2
79.40	5R	2
79.11	5R	2
18.07	5R	2
2 774.48	5R	3
74.01	5R	2
70.90	4R	1
69.76	4R	1
68.99	4R	1
64.28	4R	8
62.34	4R	2
02.1	1	10
2 658.02	2	8
2 589.14	2	8
79.6		7
79.3	1	5

W.—(*Continued*)

λ	A	S
2 572.3		6
71.46	2	6
2 488.8	2	6
46.4	1	8
2 397.11	2	10
1 895.5		6
1 788.3		5
87.0		5
85.5		5
1 679.2		3
1 550.2		3

Xe (7, 50, 175, 187)

I. Spectrum

λ	G
8 819.38	6
8 409.17	4
8 280.08	10
31.62	10
7 642.04	4
7 393.80	3
7 285.36	3
6 882.07	3
6 727.90	3
6 469.70	3
6 318.06	3
6 182.44	2
4 923.246	5
4 844.333	10
29.705	4
07.019	7
4 734.154	8
4 697.020	6
71.225?	10
24.275?	9
03.028	10
4 582.746?	4
24.680?	6
00.978	8
4 193.5	8
16.1	7
09.7	5
4 078.8	10
3 967.6	4
51.0	10
3 650.2	4

II. Spectrum

λ	G
6 557	10
6 097.6	7
51.2	7
36.2	6
5 976.5	7
5 751.1	5
19.6	6
5 667.6	6
59.5	5
16.8	6
5 531.1	7
5 472.7	7
60.4	6
39.0	8
19.2	10
5 372.4	8

Xe.—II. Spectrum.—(*Cont'd*)

λ	G
5 339.4	0
14.0	8
5 292.2	10
5 080.7	7
4 921.5	6
4 890.1	5
83.5	6
76.5	7
62.5	8
44.3	10
23.3	6
4 698.0	5
52.0	6
03.0	10
4 592.0	6
85.5	10
77.2	6
45.2	8
40.9	8
4 480.8	7
62.2	10
48.1	10
34.2	6
14.8	7
4 395.7	10
93.2	10
30.5	10
4 245.4	10
38.2	10
08.5	6
4 193.1	8
80.0	10
09.0	6
4 057.4	5
50.0	6
3 992.7	5
50.6	8
22.5	10
07.9	7
3 895.0	6
80.5	6
77.8	8
41.5	7
3 781.0	10
76.3	7
3 676.6	7
24.1	8
3 596.6	5
83.6	6
79.7	6
52.1	6
42.4	6
3 468.2	5
67.2	5
58.8	5
54.3	7
3 330.8	6
22.2	6
3 285.8	8
42.8	7
39.3	6
3 196.2	5
51.0	6

Xe.—II. Spectrum.—(*Cont'd*)

λ	G
3 150.7	6
38.3	6
3 091.1	5
83.6	6
65.2	6
2 993.0	5
79.4	6
57.7	5
37.9	6
2 871.2	5
16.0	5
14.5	6
2 794.9	5
17.4	7
2 677.2	8
05.6	10
2 475.9	10

Yb* (65, 90, 91)

λ	A	S
7 699.49	10	
7 527.58	5	
6 799.66	10	
6 667.85	10	
6 489.14	10	1
5 837.13	8	
5 720.02	10	
5 652.00	9	
5 556.47	10	1
39.05	10	
5 481.95	8	
5 352.94	5	1
35.14	6	1
5 277.07	6	
4 935.51	10	
4 786.60	10	10
81.90	8	
26.07	8	10
4 576.22	10	3
4 439.22	8	2
4 316.96	2	5
4 180.84	10	5
35.13	4	8
3 988.01	10	10
3 795.76	3	5
70.09	7	3
3 694.20	10	10
19.83	5	8
3 560.69	8	5
60.33	8	3
20.24	4	10
3 478.84	8	10
76.30	8	4
64.33	10	5
54.07	5	10
41.50	10	3
31.12	6	3
3 362.60	10	4
42.96	10	5
37.17	8	2
3 289.37	10	10
3 192.87	3	8

*Ytterbium = Neoytterbium = Aldebaranium.

Yb.—(*Continued*)

λ	A	S
3 169.05	3	8
53.86	3	10
40.91	4	10
26.1		10
17.78	4	10
07.87	10	10R
3 065.03	4	10
31.12	10	5
29.6		10
17.57	3	10
09.39	3	8
05.76	5	10
2 994.80	3	8
70.56	6	5
19.36	4	10
14.23	2	10
2 859.81	3	6
51.17	4	10
2 750.49	5	10
2 672.64	3	4
42.53	1	8
2 464.53	10R	

Yt (58, 62, 66, 78, 90, 91, 130, 145, 290)

λ	A	S
II 7 881.7	2	
II 7 450.2	4	
7 346.3	4	
II 7 264.16	4	
7 191.65	3	
6 979.87	4	
II 51.67	4	
50.32	4	
6 887.22	4	
45.23	4	
II 6 795.41	4	1
I 93.71	4	1
35.99	4	
00.71	4	1
I 6 687.57	5	1
64.37	4	
II 13.75	5	3
6 538.58	4	2
I 6 435.03	8	8
I 6 222.58	6	2
I 6 191.72	7	4
I 38.45	4	2
I 6 023.42	4	2
09.20	5	3
5 945.72	4	1
II 5 781.68	4	2
II 28.90	4	2
06.73	4R	2
5 662.95	7R	10
48.46	4R	1
44.69	4R	1
30.13	6R	2
5 581.88	5R	2
77.42	4R	1
56.45	4R	1
II 44.60	5	2
27.55	6R	3

Yt.—(*Continued*)

λ	A	S
II 5 521.62	6R	3
II 09.91	9	4
03.45	8	2
II 5 497.41	5	8
66.46	10	3
II 02.78	5	8
II 5 205.71	10	10
II 00.41	10	10
II 5 123.21	6	4
II 5 087.42	10	10
II 4 900.12	10	10
II 4 883.69	10	10
59.83	6	3
II 54.88	10	10
52.69	6	4
45.68	6	5
39.86	9	10
II 23.31	4	10
II 4 682.31	5	10
I 74.84	8	5
58.31	6	3
I 43.69	8	5
4 527.79	7	3
27.26	8	5
05.96	8	3
II 4 422.60	10	10
II 4 398.03	8	10
II 74.95	10	10
II 58.72	7	10
48.79	9	3
II 09.62	10	10
02.30	10	3
4 251.18	7	2
II 35.71	8	5
20.62	7	1
II 4 177.52	10	10
I 74.14	7	4
I 67.52	8	4
I 42.87	8R	8
I 28.32	8R	8
I 02.38	9R	8
I 4 083.71	7	3
I 77.38	6R	5
I 47.65	7	4
II 3 982.61	10	10
II 50.35	10	10
II 3 788.69	9	10
II 74.33	10	10
II 47.55	6	10
II 10.30	10	10
3 668.48	3	10
I 20.94	10	8
II 11.05	10	10
II 01.92	10	10
II 00.73	10	10
I 3 592.91	8	4
84.51	4	10
48.99	10	10
3 496.09	9	10
3 361.99	5	10
II 27.88	10	10
II 3 242.28	10	10
II 16.67	10	10

Yt.—(*Continued*)

λ	A	S
II 3 203.32	7	10
II 00.26	7	10
II 3 195.61	8	10
73.05	4	10
29.93	3	8
II 3 095.88	6	2
2 946.0		10
2 817.0	1	10
2 422.20	4	8
14.7		10
2 367.2		10

Zn, (59, 60, 62, 74, 75, 78, 90, 91, 107, 111, 123, 139, 203, 204, 206, 207, 251, 254, 273, 276, 284, 287)

λ	A	S
16 504.0	4	
I 503.9	4	
I 485.7	4	
I 15 679.7	4	
I 14 038.5	10	
I 13 786.1	4	
I 781.4	2	
I 197.5	10	
I 150.4	10	
I 053.2	10	
I 11 054.2	10	
I 10 979	4	
I 970	4	
I 7 799.1	4	
II 32.63		10
II 7 588.61		15
II 7 478.73	4	20
7 338.9	4	
7 264.2	4	
7 026.1	4	
I 6 943.4	4	
I 38.5	6	
I 28.4	8	
II 6 482.98		15
I 79.0	7	
I 6 362.345	10	10
I 6 239.20	5	
I 37.9	6	
II 14.65		12
II 6 111.56		10
II 02.54	2	20
II 6 021.26	1	15
II 5 894.39	8	20
I 5 777.1	5	
I 75.6	6	
I 72.2	8	
I 5 310.90	4	
I 10.18	6	
I 08.57	8	
I 5 181.948	5	1
II 4 924.0	10	30
II 11.6	10	25
I 4 810.534	10R	10
I 4 722.162	10R	10
I 4 680.138	10R	10

Zn.—(*Continued*)

	λ	A	S
I	4 629.810	8	
	4 057.87	6	1
II	3 840.34		15
II	06.39		10
I	3 345.9	8	2
I	45.6	8R	10
I	45.0	10R	10
I	02.9	8R	10
I	02.6	8R	10
I	3 282.30	8R	10
I	3 075.88	8R	6
I	72.10	10R	10
I	35.80	10R	6
I	18.38	6	3
I	2 802.0	3R	
I	00.8	7R	10
I	00.0	8R	
I	2 771.0	6R	
I	70.9	8R	8
I	56.47	6R	5
I	12.50	6	3
I	2 684.19	6	3
I	70.57	4	1
I	08.6	8R	3
I	2 582.5	8R	2
II	70.72		2R
I	69.92	6R	1
II	57.95	8	10
II	02.0	3	10
I	2 491.5	6	1
	2 393.80	4	1
	2 246.8	4	
I	2 138.5	3R	2R
II	00.0		5
II	2 061.9	4	4R
II	25.5	4	2R
	1 864		5
	39.3		6
	34		7
	11		7
	1 767.8		7
	50		7
	46		8
	43		10
	07		7
	1 673.2		7
	51.9		7
	45.0		8
	39.5		9
	29.4		9
	22.9		7
	20.0		6
I	01.2		6
I	1 589		10
I	1 457		8
	677.9		5

Zr (5, 61, 77, 78, 90, 91, 157, 272)

	λ	A	S
	7 318.2	3	
	7 280.3	4	
I	7 169.1	6	

Zr.—(*Continued*)

	λ	A	S
I	7 097.7	4	
	6 990.82	5	
	53.83	5	
	6 846.95	4	
	6 769.12	6	
	6 489.64	6	1
	70.21	6	1
	6 313.01	7	1
	6 299.63	7	1
I	6 143.19	7	1
I	27.44	7	1
	5 879.77	8	1
I	5 680.88	6	1
	20.13	6	1
	5 528.39	5	1
	02.13	6	1
	5 385.12	7	1
	11.39	5	1
	5 191.58	4	
	55.44	4	1
	5 064.90	5	1
	46.58	5	1
	4 959.41	5	
	09.57	6	
I	4 815.63	6	3
I	4 772.32	8	4
I	39.48	9	5
I	10.07	10	5
	4 688.45	7	4
I	87.80	10	5
	33.98	7	2
	4 575.51	7	3
I	35.75	8	3
	4 442.99	6	9
	4 379.77	8	10
	47.89	7	3
I	4 282.20	6	6
I	27.75	8	4
	4 161.21	7	8
	56.23	8	9
	49.20	10	10
I	4 081.21	9	5
	48.67	7	9
II	3 998.97	9	10
	91.13	9	10
II	58.22	8	10
	15.93	5	10
I	3 890.32	7	4
II	36.75	5	10
I	35.97	7	2
	3 796.49	3	8
	51.59	6	10
	09.27	6	10
	3 698.16	6	10
II	74.71	6	10
II	14.77	8	10
	11.89	4	8
II	3 576.86	7	10
II	72.47	10	10
II	56.60	9	10
	42.62	5	10
I	19.60	5	3
II	05.66	5	8
	05.48	4	8

Zr.—(*Continued*)

	λ	A	S
II	3 496.21	10	10
	81.15	8	10
	79.39	7	9
	63.01	4	10
II	38.23	10	10
II	30.53	7	9
II	3 391.98	10	10
II	57.26	8	4
	56.09	8	4
	3 284.71	8	4
II	79.27	8	4
II	73.05	8	9
I	3 182.87	7	5

Zr.—(*Continued*)

λ	A	S
3 106.57	6	4
3 029.52	6	1
11.74	5	1
2 985.39	4	1
68.95	6	3
2 875.98	4	
44.58	4	4
2 752.21	4	3
34.84	5	5
2 678.64	5	5
2 571.41	6	8
68.87	5	6
2 449.84	4	3

LITERATURE

(For a key to the periodicals see end of volume)

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(20) Bloch and Bloch, *34*, **178**: 472; 23. (21) Bloch, Bloch and Déjardin, *34*, **178**: 766; 23. (22) Bloch and Bloch, *34*, **179**: 1396; 24. (23) Bloch and Bloch, *51*, **2**: 229; 21. (24) Bloch and Bloch, *51*, **6**: 105; 154, 25. (25) Bögemann, *Diss.*, Münster, 1918. (26) Bowen, *2*, **29**: 231; 27. (27) Millikan and Bowen, *2*, **23**: 1; 24. (28) Bowen and Millikan, *2*, **23**: 664; 24. (29) Bowen and Millikan, *2*, **25**: 295; 25.
(30) Bowen and Millikan, *2*, **25**: 591; 25. (31) Millikan and Bowen, *2*, **25**: 600; 25. (32) Bowen and Millikan, *2*, **26**: 150; 25. (33) Bowen and Millikan, *2*, **26**: 310; 25. (34) Bowen and Millikan, *2*, **27**: 144; 26. (35) Bowen and Millikan, *2*, **28**: 256; 26. (36) Bowen and Millikan, *3*, **48**: 259; 24. (37) Buchholz, J., *Diss.*, Bonn, 1919. (38) Buchholz, N., *Diss.*, Bonn, 1918. (39) Burns, *521*, **8**: 27; 13.
(40) Burns, *521*, **7**: 149; 13. *34*, **156**: 1611; 13. *99*, **12**: 207; 13. **13**: 235; 14. (41) Burns and Meggers, *31*, No. **251**; 15. (42) Burns, *48*, **11**: 301; 25. (43) Burns, Meggers and Merrill, *31*, No. **274**; 16. (44) Burns, Meggers and Merrill, *31*, No. **329**; 18. (45) Cardaun, *99*, **14**: 56, 89; 14. (46) Carroll, *62*, **225**: 357; 26. (47) Catalán, *132*, **14**: 584; 16. (48) Catalán, *132*, **15**: 432; 17. (49) Clark, *21*, **40**: 332; 14.
(50) Collie, *5*, **97**: 349; 20. (51) Croze, *34*, **152**: 1574; 11. (52) Croze, *Diss.*, Paris, 1913. (53) Datta, *5*, **99**: 69; 21. (54) Dhein, *99*, **19**: 289; 20. (55) Dhein, *99*, **11**: 317; 12. (55.1) Dingle, *5*, **113**: 323; 26. (56) Dunoyer, *34*, **173**: 350; 21. (57) Dunoyer, *34*, **173**: 472; 21. (57.1) Dunoyer, *51*, **3**: 261; 22. (58) Eberhard, *99*, **7**: 245; 09. (59) Eder, *75*, **122 IIa**: 607; 13.
(60) Eder, *75*, **123 IIa**: 615; 14. (61) Eder, *75*, **123 IIa**: 2289; 14. (62) Eder, *75*, **124 IIa**: 101; 15. (65) Eder, *75*, **124 IIa**: 707; 15. (66) Eder, *75*, **125 IIa**: 383; 16. (67) Eder, *75*, **125 IIa**: 883; 16. (68) Eder, *75*, **125 IIa**: 1467; 16. (69) Eder, *75*, **126 IIa**: 473; 17.
(70) Eder, *75*, **127 IIa**: 1099; 18. (71) Eder, *75*, **129 IIa**: 421; 20. **131 IIa**: 199; 22. (72) Eder, *228*, **74**: 45; 03. (73) Eder and Valenta, *75*, **107 IIa**: 41; 98. (74) Eder and Valenta, *75*, **118 IIa**: 511; 09. (75) Eder and Valenta, *75*, **118 IIa**: 1077; 09. (76) Eder and Valenta, *75*, **119 IIa**: 3; 10. (77) Eder and Valenta, *75*, **119 IIa**: 9; 10. (78) Eder and Valenta, *75*, **119 IIa**: 519; 10. (79) Eder and Valenta, *228*, **60**: 241; 93.
(80) Eder and Valenta, *228*, **60**: 307; 93. (81) Eder and Valenta, *228*, **61**: 347; 94. (82) Eder and Valenta, *228*, **61**: 401; 94. (83) Eder and Valenta, *228*, **64**: 1; 96. (84) Eder and Valenta, *228*, **67**: 97; 98. (85) Eder and Valenta, *228*, **68**: 1; 99. (86) Eder and Valenta, *228*, **68**: 523; 99. (87) Eder and Valenta, *228*, **68**: 531; 99. (88) Evans, *21*, **29**: 160; 09. (89) Evershed, *62*, **201**: 457; 03.
(90) Exner and Haschek, *B86*, **II**. (91) Exner and Haschek, *B86*, **III**. (92) Fiebig, *99*, **8**: 73; 10. (93) Fowler, *520*, **73**: 62; 12. (94) Fowler, *520*, **76**: 196; 16. (95) Fowler, *520*, **80**: 692; 20. (96) Fowler, *62*, **209**: 447; 08. (97) Fowler, *5*, **89**: 133; 13. (98) Fowler, *62*, **214**: 225; 14. (98.1) Fowler, *5*, **105**: 299; 24. (99) Fowler, *5*, **107**: 31; 25.
(100) Fowler and Reynolds, *5*, **89**: 137; 13. (101) Frings, *99*, **15**: 165; 15. (102) Frost and Adams, *21*, **16**: 119; 02. (103) Fuchs, *99*, **14**: 239, 263; 14. (103.1) Gale and Monk, *21*, **59**: 125; 24. (104) Galitzin and Wilip, *504*, **19**: No. 9; 06. (105) Geuter, *99*, **5**: 1; 07. (106) Grünter, *99*, **13**: 1; 13. (107) Hagenbach and Schumacher, *99*, **19**: 129; 19. (108) Hall, *Diss.*, Bonn, 1921. (109) Hamm, *99*, **13**: 105; 14.

(110) Hampe, *99*, **13**: 348; 14. (111) Handke, *Diss.*, Berlin, 1909. (112) Hansen and Werner, *137*, **5**: No. 8; 23. (113) Hasbach, *99*, **13**: 399; 14. (114) Hasselberg, *468*, **28**: No. 6; 96. (115) Hasselberg, *468*, **36**: No. 2; 02. (116) Hasselberg, *468*, **38**: No. 5; 04. (117) Hasselberg, *468*, **45**: No. 5; 10. (118) Herpertz, *99*, **4**: 185; 06. (119) Holtz, *99*, **12**: 101; 13.

(120) Hopfield, *2*, **19**: 548; 22. (121) Hopfield, *2*, **20**: 573; 22. *21*, **59**: 114; 24. (122) Hopfield and Leifson, *21*, **58**: 59; 23. (123) Huppers, *99*, **13**: 46; 13. (123.1) Ireton, *69*, **18 III**: 103; 24. (124) Jevons, *5*, **91**: 120; 14. (125) Jevons, *5*, **103**: 193; 23, (126) Josewski, *99*, **17**: 79; 17. (127) Kail, *75*, **123 IIa**: 1267; 14. (128) Kasper, *99*, **10**: 53; 11. (129) Kayser, *76*, **1896**: 551. *21*, **4**: 1; 96.

(130) Kayser, *524*, **1903**: Anhang. (131) Kayser, *21*, **7**: 93, 173; 96. (132) Kayser and Runge, *524*, **1891**: Anhang. (133) Kayser and Runge, *524*, **1893**: Anhang No. 3. (134) Kayser and Runge, *8*, **41**: 302; 90. (135) Kayser and Runge, *8*, **43**: 384; 91. (136) Kayser and Runge, *8*, **46**: 225; 92. (137) Kayser and Runge, *8*, **48**: 126; 93. (138) Kayser and Runge, *8*, **52**: 93; 94. (139) Kayser and Runge, *8*, **52**: 114; 94.

(140) Kiess, *525*, **4**: 170; 22. (141) Kiess, *525*, **4**: 363; 22. (142) Kiess, *166*, **60**: 249; 24. (143) Kiess, *31*, No. **442**; 22. (144) Kiess, *31*, No. **466**; 23. (145) Kiess, Hopkins and Kremers, *31*, No. **421**; 21. (146) Kiess and Meggers, *31*, No. **372**; 20. (147) Kimura, *429*, **4**: 127; 20. (148) King, *21*, **48**: 13; 18. **51**: 179; 20. (149) Klein, *21*, **56**: 373; 22.

(150) Klein, *99*, **12**: 16; 13. (151) Klein, *99*, **18**: 45; 18. (152) Konen, *8*, **65**: 256; 98. (153) Krebs, *99*, **16**: 292; 17. (154) Lang, *62*, **224**: 371; 24. (155) Laufenberg, *Diss.*, Bonn, 1911. (156) Lewis, *21*, **43**: 67; 16. (157) Lohse, *Pub. Astrophys. Obs.*, Potsdam, **12**: 109; 02. (158) Lorenser, *Diss.*, Tübingen, 1913. (159) Ludwig, *99*, **16**: 157; 17.

(160) Lunt, *21*, **22**: 256; 05. (161) Lunt, *Ann. Cape Obs.*, **10 II**: 5B; 06. (161.1) Lunt, *520*, **85**: 38; 24. (162) Lyman, *21*, **33**: 98; 11. (163) Lyman, *21*, **35**: 341; 12. (164) Lyman, *21*, **38**: 282; 13. (165) Lyman, *21*, **43**: 89; 16. *2*, **3**: 503; 14. (166) Lyman, *65*, **45**: 313; 10. (167) McLennan, Ainslie and Fuller, *5*, **95**: 316; 19. (168) McLennan and Edwards, *3*, **30**: 482; 15. (169) McLennan and Young, *3*, **36**: 450; 18.

(170) McLennan, Young and Ireton, *5*, **98**: 95; 20. (171) McLennan, Young and McLay, *69*, **18 III**: 57; 24. (172) McLennan, Young and McLay, *69*, **18 III**: 77; 24. (174) Meggers, *31*, No. **312**: 18. (175) Meggers, *31*, No. **414**; 21. (175.1) Meggers, *31*, No. **499**; 25. (175.2) Meggers, National Bureau of Standards, *0.* (176) Meggers and Burns, *0.* (177) Meggers and Kiess, *31*, No. **324**; 18. (178) Meggers and Kiess, *31*, No. **479**; 24. (179) Meggers and Kiess, *31*, No. **478**; 24.

(180) Meissner, *8*, **58**: 333; 19. (181) Meissner, *8*, **50**: 713; 16. (182) Meissner, *8*, **65**: 378; 21. (183) Meissner, *63*, **15**: 668; 14. (184) Meissner, *63*, **17**: 549; 16. (185) Merrill, *21*, **46**: 357; 17. (186) Merrill, *21*, **51**: 236; 20. (187) Merrill, *31*, No. **345**: 19. (187.1) Merton and Barrat, *62*, **222**: 369; 22. (188) Merton and Pilley, *5*, **107**: 411; 25. (189) Messerschmidt, *99*, **5**: 249; 07.

(190) Millikan, *et. al.*, *21*, **53**: 150; 21. (191) Millikan, *197*, **7**: 289; 21. (192) Millikan and Bowen, *2*, **23**: 1; 24. (193) Millikan, Bowen and Sawyer, *21*, **53**: 150; 21. (194) Monk, *21*, **62**: 375; 25. (195) Morrow, *117*, **13**: 269; 12. (196) Morsch, *99*, **3**: 181; 05. (197) Müller, *Diss.*, Bonn, 1921. (198) Nacken, *99*, **12**: 54; 13. (199) Neovius, *526*, **17**: No. 8; 92.

(200) Offermann, *Diss.*, Bonn, 1920. (201) Otsuka, *96*, **36**: 786; 26. (202) Paschen, *8*, **27**: 537; 08. (203) Paschen, *8*, **29**: 625; 09. (204) Paschen, *8*, **30**: 746; 09. (205) Paschen, *8*, **33**: 717; 10. (206) Paschen, *8*, **35**: 860; 11. (207) Paschen, *8*, **40**: 602; 13. (208) Paschen, *8*, **50**: 901; 16. (209) Paschen, *8*, **60**: 405; 19. **63**: 201; 20.

(210) Paschen, *8*, **71**: 142, 537; 23. (211) Paschen and Meissner, *8*, **43**: 1223; 14. (212) Pickhan, *Diss.*, Münster, 1920. (213) Piña de Rubies, *132*, **15**: 110; 17. (214) Piña de Rubies, *132*, **15**: 215; 17. (215) Piña de Rubies, *132*, **15**: 434; 17. (216) Piña de Rubies, *132*, **16**: 338; 18. (216.1) Piña de Rubies, *34*, **181**: 108; 25. (217) Porlezza, *36*, **42 II**: 42; 12. (218) Porlezza, *22*, **20 I**: 819; 11. **20 II**: 176; 11. (219) Porlezza, *22*, **20 II**: 584, 642; 11.

(220) Priest, *128*, **2**: 1; 12. (221) Puhlmann, *99*, **17**: 97; 17. (222) Quincke, *99*, **14**: 249; 15. (223) Randall, *21*, **34**: 1; 11. (224) Randall, *21*, **42**: 195; 15. (225) Randall and Barker, *21*, **49**: 42; 19. (226) Randall and Barker, *21*, **49**: 54; 19. (227) Ranken, *Diss.*, Helsingfors, 1897. (228) Richter, *Diss.*, Bonn, 1927. (228.1) Reinheimer, *8*, **71**: 162; 23. (229) Rowland and Harrison, *21*, **7**: 273; 98.

(230) Rowland and Tatnall, *21*, **1**: 14; 95. (231) Rowland and Tatnall, *21*, **1**: 149; 95. (232) Rowland and Tatnall, *21*, **2**: 184; 95. (233) Rowland and Tatnall, *21*, **3**: 286; 96. (234) Royds, *3*, **17**: 202; 09. (235) Royds, *5*, **82**: 22; 09. (236) Ruark, *21*, **58**: 46; 23. (237) Runge, *21*, **9**: 281; 99. (238) Runge, *21*, **10**: 73; 99. (239) Runge and Paschen, *8*, **61**: 641; 97.

(240) Runge and Paschen, *21*, **8**: 70; 98. (241) Runge and Paschen, *76*, **1895**: 639, 759. (242) Runge and Precht, *8*, **14**: 418; 04. (243) Rutherford and Royds, *3*, **16**: 313; 08. (244) Rütten and Morsch, *99*, **3**: 181; 05. (245) St. John and Babcock, *21*, **53**: 260; 21. (246) St. John and Ware, *21*, **36**: 14; 12. **39**: 5; 14. (247) v. Salis, *8*, **76**: 145; 25. (248) Saltmarsh, *3*, **47**: 874; 24. (249) Saltmarsh, *5*, **108**: 332; 25.

(250) Saunders, *21*, **32**: 153; 10. **40**: 377; 14. **52**: 265; 20. (251) Saunders, *21*, **43**: 234; 16. (252) Saunders, *21*, **51**: 23; 20. (253) Saunders, *21*, **56**: 73; 22. (254) Sawyer, *21*, **52**: 286; 20. (255) Scharbach, *99*, **12**: 145; 12. (256) Schillinger, *75*, **118 IIa**: 605; 09. (257) Schippers, *99*, **11**: 235; 13. (258) Schmitz, *99*, **11**: 209; 12. (259) Schulemann, *99*, **10**: 263; 12.

(260) Schumacher, *99*, **19**: 149; 19. (261) Shaver, *69*, **18 III**: 23; 24. (262) Simeon, *5*, **102**: 484; 22. **104**: 368; 23. (262.1) Simeon, *5*, **104**: 368; 23. (263) Smythe, *21*, **54**: 133; 21. (264) Sommer, *8*, **75**: 163; 24. (265) Stiles, *21*, **30**: 48; 09. (266) Symons, *99*, **12**: 277; 13. (267) Takamine and Nitta, *429*, **2**: 117; 17. (268) Turner, *2*, **27**: 397; 26. (269) Uhler and Browning, *12*, **42**: 389; 16.

(270) Uhler and Patterson, *12*, **36**: 135; 13. (271) Uhler and Tanch, *21*, **55**: 291; 22. (272) Vahle, *99*, **18**: 84; 18. (273) Volk, *Diss.*, Tübingen, 1914. (274) Wagner, *99*, **10**: 69; 11. (275) Wallrath, *Diss.*, Bonn, 1923. (276) Walters, *31*, No. **411**; 21. (277) Watson, *5*, **81**: 181; 08. (278) Watson, *5*, **82**: 189; 09. (279) Watson, *5*, **83**: 50; 09.

(280) Watteville, *99*, **7**: 279; 09. (281) Weigand, *99*, **11**: 261; 12. (282) Weinberg, *5*, **107**: 138; 25. (283) Wiedman, *8*, **38**: 1041; 12. (284) Wiedmann, *Diss.*, Tübingen, 1912. (285) Wirminghaus, *99*, **20**: 229; 21. (286) Wolff, *99*, **3**: 395; 05. (287) Wolff, *8*, **42**: 825; 13. (288) Wood and Fortrat, *21*, **43**: 73; 16. (289) Wood and Kimura, *21*, **46**: 181; 17.

(290) Yntema and Hopkins, *43*, **6**: 121; 22. (291) Zumstein, *2*, **28**: 150; 26.

PERSISTENT LINES AND RAIES ULTIMES OF THE CHEMICAL ELEMENTS

W. F. MEGGERS

The spectrochemical detection of the chemical elements is based on the identification of certain spectral lines which are characteristic of the atoms, and the most sensitive lines depend, in general, on the type of excitation. Sources in which the excitation is moderate (flames, ordinary arcs, uncondensed discharges in Geissler tubes) leave most of the atoms in a neutral condition, and the class *I* spectra predominate. More vigorous excitations (high potential condensed sparks, discharges in gas or vapor at low pressure, etc.) which ionize most of the atoms develop the class *II* spectra, while still more violent discharges bring out the *III* and higher classes of spectra corresponding to successive stages of ionization. Successive ionizations are increasingly difficult to produce, the spectra shift into the far ultraviolet and are for the most part still unknown; practical spectrochemical identifications are therefore limited almost entirely to arc and first spark spectra. The following lines have been established empirically or from the rules of spectral structure to be persistent in these spectra; the most sensitive line or *raie ultime* is printed in bold face. In many cases, *e.g.*, the halogens, the true *raies ultimes* lie in the Schumann region (vacuum spectroscopy), and the persistent lines in the region readily observed by ordinary spectrographic methods (2000 to 9000 Å) are far less sensitive.

The true *raies ultimes* are the strongest lines in the spectra; they arise from the most probable electron transitions in the atom. In general, the excitation of these lines involves a transition of a single electron in such a way that the atomic energy is changed from the normal state to one in which the quantum numbers l and j are each increased by one unit. The combinations of spectral terms (energy states) giving rise to these lines appear in the last column; they show which spectra have been analyzed as to spectral structure and describe the normal states of the atoms (l = 0, 1, 2, 3, etc., for S, P, D, F, etc., terms; j, the inner quantum number, appears as a subscript to the term symbol; *v.* p. 392).

PERSISTENT LINES AND RAIES ULTIMES

Arranged by Elements

The wave-lengths (λ) tabulated below refer to air at 15°C and 1 atm., except those shorter than 1800 Å, which are vacuum values.

Unit of λ = 1 Å = 10^{-8} cm.

A *I*

λ	Terms
1048.26	$p—s_2$
1066.70	$p—s_4$
6965.430	$s_5—p_2$
7067.217	$s_5—p_3$
7503.868	$s_2—p_1$
8115.308	$s_5—p_9$

Ag *I*

λ	Terms
3280.67	$^2S_1—^2P_2$
3382.89	$^2S_1—^2P_1$

Ag *II*

λ	Terms
2246.43	$^3D_3—^3F_4$
2437.77	$^3D_3—^3P_2$

Al *I*

λ	Terms
3082.162	$^2P_1—^2D_2$
3092.718	$^2P_2—^2D_3$
3092.85	$^2P_2—^2D_2$
3944.025	$^2P_1—^2S_1$
3961.537	$^2P_2—^2S_1$

Al *II*

λ	Terms
1671.0	$^1S_0—^1P_1$
1856.00	$^3P_0—^3S_1$
1858.13	$^3P_1—^3S_1$
1862.48	$^3P_2—^3S_1$

Al *III*

λ	Terms
1854.67	$^2S_1—^2P_2$
1862.90	$^2S_1—^2P_1$

As *I*

λ	Terms
1889.9	$^4S_2—^4P_3$
1936.9	$^4S_2—^4P_2$
1972.0	$^4S_2—^4P_1$
2288.14	$^2D_3—^2P_2$
2349.84	$^2D_2—^2P_1$
2780.23	$^2P'_2—^2P_2$
2860.46	$^2P'_1—^2P_1$

Au *I*

λ	Terms
2427.96	$^2S_1—^2P_2$
2675.95	$^2S_1—^2P_1$

B *I*

λ	Terms
2496.778	$^2P_1—^2S_1$
2497.733	$^2P_2—^2S_1$

B *II*

λ	Terms
1362.46	$^1S_0—^1P_1$
3452.33	

Ba *I*

λ	Terms
5424.63	$^3P_2—^3D_3$
5519.11	$^3P_1—^3D_2$
5535.53	$^1S_0—^1P_1$
5777.7	$^3P_0—^3D_1$

Ba *II*

λ	Terms
4554.037	$^2S_1—^2P_2$
4934.09	$^2S_1—^2P_1$

Be *I*

λ	Terms
2348.62	$^1S_0—^1P_1$
3321.01	$^3P_0—^3S_1$
3321.09	$^3P_1—^3S_1$
3321.35	$^3P_2—^3S_1$

Be *II*

λ	Terms
3130.42	$^2S_1—^2P_2$
3131.06	$^2S_1—^2P_1$

Bi *I*

λ	Terms
2061.71	$^4S_2—^4P_3$
2276.57	$^4S_2—^4P_2$
2780.52	$^2D_2$

Bi *I*.—(*Continued*)

λ	Terms
2809.63	$^2D_3—^2P_2$
2897.98	$^2D_2—^2P_1$
2938.31	$^2D_3$
2989.04	$^2D_2$
3067.73	$^4S_2—^4P_1$

Br *I*

λ	Terms
1540.8	
1633.8	

Br *II*(?)

λ	Terms
4704.83	
4785.48	
4816.72	

C *I*

λ	Terms
2478.6	$^1S_0—^1P_1$

C *II*

λ	Terms
1334.54	$^2P_1—^2D$
1335.72	$^2P_2—^2D$
4267.02	$^2D_2—^2F_3$
4267.27	$^2D_3—^2F_4$

Ca *I*

λ	Terms
4226.728	$^1S_0—^1P_1$
4454.780	$^3P_0—^3D_1$
4455.880	$^3P_1—^3D_2$
4456.62	$^3P_2—^3D_3$

Ca *II*

λ	Terms
3933.670	$^2S_1—^2P_2$
3968.475	$^2S_1—^2P_1$

Cb *I*

λ	Terms
4058.97	$^6D_5—^6F_6$
4079.73	$^6D_4—^6F_5$
4100.97	$^6D_3—^6F_4$
4123.85	$^6D_2—^6F_3$
4137.13	$^6D_1—^6F_2$

Cb *II*

λ	Terms
3094.19	$^5F_5—^5G_6$
3130.78	$^5F_4—^5G_5$
3163.37	$^5F_3—^5G_4$
3194.95	$^5F_2—^5G_3$
3225.47	$^5F_1—^5G_2$

Cd *I*

λ	Terms
2288.03	$^1S_0—^1P_1$
3403.653	$^3P_0—^3D_1$
3466.201	$^3P_1—^3D_2$
3610.510	$^3P_2—^3D_3$

Cd *II*

λ	Terms
2144.39	$^2S_1—^2P_2$
2265.03	$^2S_1—^2P_1$

Ce *II*

λ	Terms
4012.40	
4040.76	
4165.61	
4186.60	

Cl *I*

λ	Terms
1379.6	
1396.5	
4794.5	
4810.0	
4819.4	

Co *I*

λ	Terms
3453.514	$^4F_5—^4G_6$
3465.794	$^4F_5—^4G_6$
3529.814	$^4F_4—^4G_5$

Co *II*

λ	Terms
2286.16	$^6F_5—^5G_6$
2307.84	$^5F_4—^6G_5$
2378.62	$^5F_5—^5D_4$
2388.90	$^5F_5—^5F'_5$

Cr *I*

λ	Terms
4254.342	$^7S_3—^7P_4$
4274.802	$^7S_3—^7P_3$
4289.725	$^7S_3—^7P_2$
5204.54	$^5S_2—^5P_1$
5206.039	$^5S_2—^5P_2$
5208.429	$^5S_2—^5P_3$

Cr *II*

λ	Terms
2835.64	$^6D_5—^6F_6$
2843.25	$^6D_4—^6F_5$
2849.83	$^6D_3—^6F_4$
2855.66	$^6D_2—^6F_3$
2860.94	$^6D_1—^6F_2$

Cs *I*

λ	Terms
8521.15	$^2S_1—^2P_2$
8943.6	$^2S_1—^2P_1$
4555.3	$^2S_1—^2P_2$
4593.2	$^2S_1—^2P_1$

Cu *I*

λ	Terms
3247.548	$^2S_1—^2P_2$
3273.964	$^2S_1—^2P_1$

Cu *II*

λ	Terms
2135.98	$^3D_3—^3F_4$
2192.27	$^3D_2—^3F_3$
2247.80	$^3D_3—^3P_2$

Dy *I*

λ	Terms
4000.50	
4046.00	
4077.98	
4167.99	
4211.74	

Er *I*

λ	Terms
3499.12	
3692.65	
3906.34	

Eu *I*

λ	Terms
4129.72	
4205.03	

F *I*

λ	Terms
6856.01	$^4P_3—^4D_4$
6902.46	$^4P_2—^4D_3$

Fe *I*

λ	Terms
3719.938	$^5D_4—^5F_5$
3737.135	$^5D_3—^5F_4$
3745.564	$^5D_2—^5F_3$
3748.264	$^5D_1—^5F_2$
3745.902	$^5D_0—^5F_1$

Fe *II*

λ	Terms
2382.04	$^6D_5—^6F_6$
2395.63	$^6D_4—^6F_5$
2404.886	$^6D_3—^6F_4$
2410.53	$^6D_2—^6F_3$
2413.312	$^6D_1—^6F_2$

Ga *I*

λ	Terms
4033.01	$^2P_1—^2S_1$
4172.05	$^2P_2—^2S_1$

Gd *I*

λ	Terms
3646.19	
3768.40	

Ge *I*

λ	Terms
2651.15	$^3P'_2—^3P_2$
2651.60	$^3P'_1—^3P_1$
3039.08	$^1D_2—^1P_1$
3269.49	$^1D_2—^3P_1$
4226.61	$^1S_0—^1P_1$

Gl; *v.* Be

H *I*

λ	Terms
1215.7	$R\left(\frac{1}{1^2}—\frac{1}{2^2}\right)$
6562.79	$R\left(\frac{1}{2^2}—\frac{1}{3^2}\right)$
4861.33	$R\left(\frac{1}{2^2}—\frac{1}{4^2}\right)$

He *I*

λ	Terms
584.4	$^1S_0—^1P_1$
3888.64	$^3S_1—^3P_2$
5875.63	$^3P_2—^3D_3$

He *II*

λ	Terms
303.8	$4R\left(\frac{1}{1^2}—\frac{1}{2^2}\right)$
1640.5	$4R\left(\frac{1}{2^2}—\frac{1}{3^2}\right)$
4685.81	$4R\left(\frac{1}{3^2}—\frac{1}{4^2}\right)$

Hf *I*

λ	Terms
2898.25	
2904.42	
2916.48	
2940.76	
3072.88	
4093.17	

Hf *II*

λ	Terms
2513.02	
2516.88	
2641.42	
2773.36	
2820.23	
3134.72	

Hg *I*

λ	Terms
1849.6	$^1S_0—^1P_1$
2536.52	$^1S_0—^3P_1$
3650.15	$^3P_2—^3D_3$
3654.83	$^3P_1—^3D_2$
3662.88	$^3P_0—^3D_1$

Hg *II*

λ	Terms
1649.8	$^2S_1—^2P_2$
1942.3	$^2S_1—^2P_1$

Ho *I*

λ	Terms
3748.19	
3891.02	

Ho *II*

λ	Terms
2936.8	

I *I*

λ	Terms
1782.9	
2062.1	
5161.2	
5464.6	

In *I*

λ	Terms
4101.76	$^2P_1—^2S_1$
4511.31	$^2P_2—^2S_1$

Ir *I*

λ	Terms
2849.74	
2924.81	
3220.79	
3437.05	
3513.67	

K *I*

λ	Terms
4044.16	$^2S_1—^2P_2$
4047.22	$^2S_1—^2P_1$
7664.94	$^2S_1—^2P_2$
7699.01	$^2S_1—^2P_1$

Kr *I*

λ	Terms
5570.291	
5870.917	

La *I*

λ	Terms
5455.11	$^2D_3—^2D'_3$
5930.59	$^2D_3—^2F_4$
6249.92	$^4F_5—^4G_6$

La *II*

λ	Terms
3949.10	$^3D_3—^3F_4$
4077.35	$^3D_1—^3F_2$
4123.23	$^3D_2—^3F_3$

Li *I*

λ	Terms
3232.67	$^2S_1—^2P_{1,2}$
6707.86	$^2S_1—^2P_{1,2}$

Lu *I*

λ	Terms
4518.54	

Lu *II*

λ	Terms
2894.86	
2911.40	
3397.02	
3472.49	
3554.43	

Mg *I*

λ	Terms
2852.130	$^1S_0—^1P_1$
3829.36	$^3P_0—^3D_1$
3832.31	$^3P_1—^3D_2$
3838.29	$^3P_2—^3D_3$

Mg *II*

λ	Terms
2795.540	$^2S_1—^2P_2$
2802.712	$^2S_1—^2P_1$

Mn *I*

λ	Terms
4030.760	$^6S_5—^6P_4$
4033.074	$^6S_5—^6P_3$
4034.489	$^6S_5—^6P_2$

Mn *II*

λ	Terms
2576.12	$^7S_3—^7P_4$
2593.733	$^7S_3—^7P_3$
2605.69	$^7S_3—^7P_2$

Mo *I*

λ	Terms
3798.26	$^5S_2—^5P_3$
3864.12	$^5S_2—^5P_2$
3902.96	$^5S_2—^5P_1$

Mo *II*

λ	Terms
2816.15	$^6D_5—^6F_6$
2848.21	$^6D_4—^6F_5$
2871.50	$^6D_3—^6F_4$
2891.00	$^6D_2—^6F_3$
2909.11	$^6D_1—^6F_2$

N *I*

λ	Terms
1199.5	$^4S_2—^4P_3$
1200.2	$^4S_2—^4P_2$
1200.7	$^4S_2—^4P_1$
4099.96	$^2P_1—^2D_2$
4109.94	$^2P_2—^2D_3$

N *II*

λ	Terms
5666.6	$^3P_1—^3D_2$
5675.9	$^3P_0—^3D_1$
5679.5	$^3P_2—^3D_3$

N *III*

λ	Terms
989.8	$^2P_1—^2D$
991.6	$^2P_2—^2D$
4097.3	$^2P_1—^2S_1$
4103.4	$^2P_2—^2S_1$

Na *I*

λ	Terms
3302.34	$^2S_1—^2P_2$
3302.94	$^2S_1—^2P_1$
5889.965	$^2S_1—^2P_2$
5895.932	$^2S_1—^2P_1$

Nb; *v.* Cb

Nd *I*

λ	Terms
3951.15	
4177.34	
4303.61	

Ne *I*

λ	Terms
735.95	$p—s_4$
743.73	$p—s_2$
5400.56	$s_4—p_1$
5832.488	$s_2—p_1$
6402.246	$s_5—p_9$

Ni *I*

λ	Terms
3414.771	$^3D_3—^3F_4$
3492.965	$^3D_2—^3P_1$
3515.057	$^3D_2—^3F_3$
3524.543	$^3D_3—^3P_2$

Ni *II*

λ	Terms
2253.9	$^4F_2—^4G_3$
2264.45	$^4F_3—^4G_4$
2270.24	$^4F_4—^4G_5$
2287.1	$^4F_5—^4G_6$

O *I*

λ	Terms
1302.27	$^3P_2—^3S_1$
1304.96	$^3P_1—^3S_1$
1306.12	$^3P_0—^3S_1$
7771.97	$^5S_2—^5P_3$
7774.01	$^5S_2—^5P_2$
7775.68	$^5S_2—^5P_1$

Os *I*

λ	Terms
3262.30	
3267.94	
3301.56	
3752.54	
3782.20	

P *I*

λ	Terms
1774.8	$^4S_2—^4P_3$
1782.7	$^4S_2—^4P_2$
1787.5	$^4S_2—^4P_1$
2136.8	$^2D_3—^2P_2$
2149.8	$^2D_2—^2P_1$
2536.38	$^2P'_2—^2P_2$
2554.02	$^2P'_1—^2P_1$

Pb *I*

λ	Terms
2170.0	$^3P_0—^3D_1$
2833.07	$^3P'_0—^3P_1$
3639.584	$^3P_1—^3P'_1$
3683.472	$^3P_1—^3P'_0$
4057.830	$^3P_2—^3P'_1$

Pb *II*

λ	Terms
1682.4	$^2P_1—^2S_1$
2203.57	$^2P_2—^2S_1$

Pd *I*

λ	Terms
3404.59	$^3D_3$—$^3F_4$
3421.23	$^3D_2$—$^3D'_2$
3516.95	$^3D_2$—$^3P_1$
3609.55	$^3D_2$—$^3F_3$
3634.68	$^3D_3$—$^3P_2$

Pd *II*

2488.92	
2498.79	
2505.72	
2658.74	
2854.60	

Pr *I*

4062.83	
4179.43	
4189.52	
4225.34	

Pt *I*

2659.44	$^3D_3$—7_4
2830.29	$^3D_3$—4_3
2929.79	$^3D_3$—3_3
2997.96	$^1D_2$—3_3
3064.71	$^3D_3$—1_2

Ra *I*

4825.94	$^1S_0$—$^1P_1$

Ra *II*

3814.44	$^2S_1$—$^2P_2$
4682.20	$^2S_1$—$^2P_1$

Rb *I*

4201.81	$^2S_1$—$^2P_2$
4215.58	$^2S_1$—$^2P_1$
7800.30	$^2S_1$—$^2P_2$
7947.63	$^2S_1$—$^2P_1$

Rh *I*

3323.10	$^4F_4$—$^4G_5$
3396.82	$^4F_5$—$^4F'_5$
3434.90	$^4F_5$—$^4G_6$
3657.99	$^4F_4$—$^4D_3$
3692.35	$^4F_5$—$^4D_4$

Ru *I*

3436.74	$^5F_4$—$^5G_5$
3498.95	$^5F_5$—$^5G_6$
3596.17	$^5F_3$—$^5G'_4$

Ru *II*

2678.73	
2692.10	
2712.40	
2945.67	
2965.55	
2976.58	

S *I*

1807.4	$^3P_2$—$^3S_1$
1820.5	$^3P_1$—$^3S_1$
1826.4	$^3P_0$—$^3S_1$
4694.2	$^5S_2$—$^5P_3$
4695.5	$^5S_2$—$^5P_2$
4696.3	$^5S_2$—$^5P_1$
9212.8	$^5S_2$—$^5P_3$
9228.2	$^5S_2$—$^5P_2$
9237.7	$^5S_2$—$^5P_1$

Sa *I*

4390.87	
4424.35	
4434.34	

Sb *I*

λ	Terms
2068.38	$^4S_2$—$^4P_3$
2175.88	$^4S_2$—$^4P_2$
2311.50	$^4S_2$—$^4P_1$
2528.53	$^2D_3$—$^2P_2$
2598.08	$^2D_2$—$^2P_1$
3232.52	$^2P'_2$—$^2P_2$
3267.48	$^2P'_1$—$^2P_1$

Sc *I*

3907.49	$^2D_2$—$^2F_3$
3911.81	$^2D_3$—$^2F_4$

Sc *II*

3613.83	$^3D_3$—$^3F_4$
3630.75	$^3D_2$—$^3F_3$
3642.81	$^3D_1$—$^3F_2$

Se *I*

1960.2	$^3P_2$—$^3S_1$
2039.7	$^3P_1$—$^3S_1$
2062.6	$^3P_0$—$^3S_1$
4730.9	$^5S_2$—$^5P_3$
4739.1	$^5S_2$—$^5P_2$
4742.3	$^5S_2$—$^5P_1$

Si *I*

2506.904	$^3P_1$—$^3P'_2$
2516.119	$^3P_2$—$^3P'_2$
2528.516	$^3P_2$—$^3P'_1$
2881.587	$^1D_2$—$^1P_1$
3905.52	$^1S_0$—$^1P_1$

Si *II*

1526.83	$^2P_1$—$^2S_1$
1533.55	$^2P_2$—$^2S_1$

Sn *I*

2839.987	$^3P_2$—$^3P'_2$
2863.322	$^3P_0$—$^3P'_1$
3009.135	$^3P_1$—$^3P'_1$
3034.116	$^3P_1$—$^3P'_0$
3175.047	$^3P_2$—$^3P'_1$
3262.33	$^1D_2$—$^1P_1$
4524.74	$^1S_0$—$^1P_1$

Sr *I*

4607.342	$^1S_0$—$^1P_1$
4832.07	$^3P_2$—$^3D_3$
4872.48	$^3P_1$—$^3D_2$
4962.25	$^3P_0$—$^3D_1$

Sr *II*

4077.714	$^2S_1$—$^2P_2$
4215.515	$^2S_1$—$^2P_1$

Ta *I*

3311.14	
3318.85	
3406.65	

Tb *I*

3509.18	
3561.75	
3848.76	
3874.19	

Te *I*

2142.75	$^3P_2$—$^3S_1$
2383.27	$^3P_0$—$^3S_1$
2385.78	$^3P_1$—$^3S_1$
2530.73	$^3P_1$—$^5S_2$
2769.65	$^1D_2$—$^3S_1$

Th *I*

λ	Terms
3538.75	
3601.05	
4019.14	

Th *II*

3290.59	

Ti *I*

3635.467	$^3F_2$—$^3G_3$
3642.680	$^3F_3$—$^3G_4$
3653.497	$^3F_4$—$^3G_5$
4981.73	$^5F_5$—$^5G_6$
4991.07	$^5F_4$—$^5G_5$
4999.511	$^5F_3$—$^5G_4$
5007.214	$^5F_2$—$^5G_3$
5014.25	$^5F_1$—$^5G_2$

Ti *II*

3349.039	$^4F_5$—$^4G_6$
3361.215	$^4F_4$—$^4G_5$
3372.80	$^4F_3$—$^4G_4$
3383.765	$^4F_2$—$^4G_3$

Tl *I*

3775.73	$^2P_1$—$^2S_1$
5350.47	$^2P_2$—$^2S_1$

Tu *I*

3462.21	
3761.34	
3761.91	

U *I*

3552.20	
3672.59	
4241.68	

V *I*

3183.415	$^4F_3$—$^4G_4$
3183.96	$^4F_4$—$^4G_5$
3184.00	$^4F_2$—$^4G_3$
3185.406	$^4F_5$—$^4G_6$

V *II*

3093.13	$^5F_5$—$^5G_6$
3102.30	$^5F_4$—$^5G_5$
3110.71	$^5F_3$—$^5G_4$
3118.38	$^5F_2$—$^5G_3$
3125.29	$^5F_1$—$^5G_2$

W *I*

4008.76	$^7S_3$—$^7P_4$
4294.62	$^7S_3$—X_2
4302.12	$^7S_3$—$^5P_3$

W *II*

2397.11	
2589.2	
3613.79	

Xe *I*

1295.8	p—s_2
1469.9	p—s_4
4500.978	
4624.275	
4671.225	

Yt *I*

4643.69	$^2D_2$—$^2F_3$
4674.84	$^2D_3$—$^2F_4$

Yt *II*

3710.30	$^3D_3$—$^3F_4$
3774.33	$^3D_2$—$^3F_3$
3788.69	$^3D_1$—$^3F_2$

Yb *I*

λ	Terms
3289.37	
3694.20	
3988.01	

Zn *I*

2138.5	$^1S_0$—$^1P_1$
3282.32	$^3P_0$—$^3D_1$
3302.6	$^3P_1$—$^3D_2$
3344.5	$^3P_2$—$^3D_3$

Zn *II*

λ	Terms
2025.5	$^2S_1$—$^2P_2$
2061.9	$^2S_1$—$^2P_1$

Zr *I*

3519.605	$^3F_4$—$^3G_5$
3547.691	$^3F_3$—$^3G_4$
3601.19	$^3F_2$—$^3G_3$
4687.803	$^5F_5$—$^5G_6$
4710.075	$^5F_4$—$^5G_5$

Zr *I*.—(*Continued*)

λ	Terms
4739.477	$^5F_3$—$^5G_4$
4772.313	$^5F_2$—$^5G_3$
4815.62	$^5F_1$—$^5G_2$

Zr *II*

3391.976	$^4F_5$—$^4G_6$
3438.23	$^4F_4$—$^4G_5$
3496.208	$^4F_3$—$^4G_4$
3572.472	$^4F_2$—$^4G_3$

Persistent Lines and Raies Ultimes

Arranged by wave-lengths

Unit of λ = 1 Å = 10^{-8} cm.

303.8	He	*II*
584.4	He	*I*
735.95	Ne	*I*
743.73	Ne	*I*
989.8	N	*III*
991.6	N	*III*
1048.26	A	*I*
1066.70	A	*I*
1199.5	N	*I*
1200.2	N	*I*
00.7	N	*I*
15.7	H	*I*
95.8	Xe	*I*
1302.27	O	*I*
04.96	O	*I*
06.12	O	*I*
34.54	C	*II*
35.72	C	*II*
62.46	B	*II*
79.6	Cl	*I*
96.5	Cl	*I*
1469.9	Xe	*I*
1526.83	Si	*II*
33.55	Si	*II*
40.8	Br	*I*
1633.8	Br	*I*
40.5	He	*II*
49.8	Hg	*II*
71.0	Al	*II*
82.4	Pb	*II*
1774.8	P	*I*
82.7	P	*I*
82.9	I	*I*
87.5	P	*I*
1807.4	S	*I*
20.5	S	*I*
26.4	S	*I*
49.6	Hg	*I*
54.67	Al	*III*
56.00	Al	*II*
58.13	Al	*II*
62.48	Al	*II*
62.90	Al	*III*
89.9	As	*I*
1936.9	As	*I*
42.3	Hg	*II*
60.2	Se	*I*
72.0	As	*I*
2025.5	Zn	*II*
39.7	Se	*I*
61.71	Bi	*I*
2061.9	Zn	*II*
62.1	I	*I*
62.6	Se	*I*
68.38	Sb	*I*
2135.98	Cu	*II*
36.8	P	*I*
38.5	Zn	*I*
42.75	Te	*I*
44.39	Cd	*II*
49.8	P	*I*
70.0	Pb	*I*
75.88	Sb	*I*
92.27	Cu	*II*
2203.57	Pb	*II*
46.43	Ag	*II*
47.80	Cu	*II*
53.9	Ni	*II*
64.45	Ni	*II*
65.03	Cd	*II*
70.24	Ni	*II*
76.57	Bi	*I*
86.16	Co	*II*
87.1	Ni	*II*
88.03	Cd	*I*
88.14	As	*I*
2307.84	Co	*II*
11.50	Sb	*I*
48.62	Be	*I*
49.84	As	*I*
78.62	Co	*II*
82.04	Fe	*II*
83.27	Te	*I*
85.78	Te	*I*
88.90	Co	*II*
95.63	Fe	*II*
97.11	W	*II*
2404.886	Fe	*II*
10.53	Fe	*II*
13.312	Fe	*II*
27.96	Au	*I*
37.77	Ag	*II*
78.6	C	*I*
88.92	Pd	*II*
96.778	B	*I*
97.733	B	*I*
98.79	Pd	*II*
2505.72	Pd	*II*
06.904	Si	*I*
13.02	Hf	*II*
16.119	Si	*I*
16.88	Hf	*II*
2528.516	Si	*I*
28.53	Sb	*I*
30.73	Te	*I*
36.38	P	*I*
36.52	Hg	*I*
54.02	P	*I*
76.12	Mn	*II*
89.2	W	*II*
93.733	Mn	*II*
98.08	Sb	*I*
2605.69	Mn	*II*
41.42	Hf	*II*
51.15	Ge	*I*
51.60	Ge	*I*
58.74	Pd	*II*
59.44	Pt	*I*
75.95	Au	*I*
78.73	Ru	*II*
92.10	Ru	*II*
2712.40	Ru	*II*
69.65	Te	*I*
73.36	Hf	*II*
80.23	As	*I*
80.52	Bi	*I*
95.540	Mg	*II*
2802.712	Mg	*II*
09.63	Bi	*I*
16.15	Mo	*II*
20.23	Hf	*II*
30.29	Pt	*I*
33.07	Pb	*I*
35.64	Cr	*II*
39.987	Sn	*I*
43.25	Cr	*II*
48.21	Mo	*II*
49.74	Ir	*II*
49.83	Cr	*II*
52.130	Mg	*I*
54.60	Pd	*II*
55.66	Cr	*II*
60.46	As	*I*
60.94	Cr	*II*
63.322	Sn	*I*
71.50	Mo	*II*
81.587	Si	*I*
91.00	Mo	*II*
94.86	Lu	*II*
97.98	Bi	*I*
98.25	Hf	*I*
2904.42	Hf	*I*
09.11	Mo	*II*

PERSISTENT LINES AND RAIES ULTIMES.—Arranged by wave lengths.—(*Continued*)

2911.40	Lu	*II*	3290.59	Th	*II*	3596.17	Ru	*I*	3907.49	Sc	*I*	4226.61	Ge	*I*	4934.09	Ba	*II*
16.48	Hf	*I*	3301.56	Os	*I*	3601.05	Th	*I*	**11.81**	Sc	*I*	**26.728**	Ca	*I*	62.25	Sr	*I*
24.81	Ir	*I*	02.34	Na	*I*	01.19	Zr	*I*	**33.670**	Ca	*II*	41.68	U	*I*	81.73	Ti	*I*
29.79	Pt	*I*	02.6	Zn	*I*	09.55	Pd	*I*	44.025	Al	*I*	**54.342**	Cr	*I*	91.07	Ti	*I*
36.8	Ho	*II*	02.94	Na	*I*	10.510	Cd	*I*	**49.10**	La	*II*	67.02	C	*II*	99.511	Ti	*I*
38.31	Bi	*I*	**11.14**	Ta	*I*	13.79	W	*II*	51.15	Nd	*I*	67.27	C	*II*	5007.214	Ti	*I*
40.76	Hf	*I*	18.85	Ta	*I*	**13.83**	Sc	*II*	**61.537**	Al	*I*	74.802	Cr	*I*	14.25	Ti	*I*
45.67	Ru	*II*	21.01	Be	*I*	30.75	Sc	*II*	68.475	Ca	*II*	89.725	Cr	*I*	5161.2	I	*I*
65.55	Ru	*II*	21.09	Be	*I*	34.68	Pd	*I*	88.01	Yb	*I*	94.62	W	*I*	5204.54	Cr	*I*
76.58	Ru	*II*	21.35	Be	*I*	35.467	Ti	*I*	4000.50	Dy	*I*	4302.12	W	*I*	06.039	Cr	*I*
89.04	Bi	*I*	23.10	Rh	*I*	39.584	Pb	*I*	**08.76**	W	*I*	03.61	Nd	*I*	08.429	Cr	*I*
97.96	Pt	*I*	44.5	Zn	*I*	42.680	Ti	*I*	12.40	Ce	*II*	90.87	Sa	*I*	**5350.47**	Tl	*I*
3009.135	Sn	*I*	**49.039**	Ti	*II*	42.81	Sc	*II*	19.14	Th	*I*	4424.35	Sa	*I*	5400.56	Ne	*I*
34.116	Sn	*I*	61.215	Ti	*II*	46.19	Gd	*I*	**30.760**	Mn	*I*	34.34	Sa	*I*	24.63	Ba	*I*
39.08	Ge	*I*	72.80	Ti	*II*	50.15	Hg	*I*	33.01	Ga	*I*	54.780	Ca	*I*	55.11	La	*I*
64.71	Pt	*I*	82.89	Ag	*I*	**53.497**	Ti	*I*	33.074	Mn	*I*	55.880	Ca	*I*	64.6	I	*I*
67.73	Bi	*I*	83.765	Ti	*II*	54.83	Hg	*I*	34.489	Mn	*I*	56.62	Ca	*I*	5519.11	Ba	*I*
72.88	Hf	*I*	**91.976**	Zr	*II*	57.99	Rh	*I*	40.76	Ce	*II*	4500.978	Xe	*I*	**35.53**	Ba	*I*
82.162	Al	*I*	96.82	Rh	*I*	62.88	Hg	*I*	44.16	K	*I*	**11.31**	In	*I*	70.291	Kr	*I*
92.718	Al	*I*	97.02	Lu	*II*	72.59	U	*I*	46.00	Dy	*I*	18.54	Lu	*I*	5666.6	N	*II*
92.85	Al	*I*	3403.653	Cd	*I*	83.472	Pb	*I*	47.22	K	*I*	24.74	Sn	*I*	75.9	N	*II*
93.13	V	*II*	**04.59**	Pd	*I*	92.35	Rh	*I*	57.830	Pb	*I*	**54.037**	Ba	*II*	79.5	N	*II*
94.19	Cb	*II*	06.65	Ta	*I*	92.65	Er	*I*	**58.97**	Cb	*I*	55.3	Cs	*I*	5777.7	Ba	*I*
3102.30	V	*II*	**14.771**	Ni	*I*	94.20	Yb	*I*	62.83	Pr	*I*	93.2	Cs	*I*	5832.488	Ne	*I*
10.71	V	*II*	21.23	Pd	*I*	**3710.30**	Yt	*II*	77.35	La	*II*	**4607.342**	Sr	*I*	70.917	Kr	*I*
18.38	V	*II*	**34.90**	Rh	*I*	**19.938**	Fe	*I*	**77.714**	Sr	*II*	24.275	Xe	*I*	75.63	He	*I*
25.29	V	*II*	36.74	Ru	*I*	37.135	Fe	*I*	77.98	Dy	*I*	43.69	Yt	*I*	**89.965**	Na	*I*
30.42	Be	*II*	37.05	Ir	*I*	45.564	Fe	*I*	79.73	Cb	*I*	71.225	Xe	*I*	95.932	Na	*I*
30.78	Cb	*II*	38.23	Zr	*II*	45.902	Fe	*I*	93.17	Hf	*I*	**74.84**	Yt	*I*	**5930.59**	La	*I*
31.06	Be	*II*	52.33	B	*II*	48.19	Ho	*I*	97.3	N	*III*	82.20	Ra	*II*	6249.92	La	*I*
34.72	Hf	*II*	**53.514**	Co	*I*	48.264	Fe	*I*	99.96	N	*I*	85.81	He	*II*	6402.246	Ne	*I*
63.37	Cb	*II*	62.21	Tu	*I*	52.54	Os	*I*	4100.97	Cb	*I*	87.803	Zr	*I*	6562.79	H	*I*
75.047	Sn	*I*	65.794	Co	*I*	61.34	Tu	*I*	01.76	In	*I*	94.2	S	*I*	**6707.86**	Li	*I*
83.415	V	*I*	66.201	Cd	*I*	61.91	Tu	*I*	03.4	N	*III*	95.5	S	*I*	6856.01	F	*I*
83.96	V	*I*	72.49	Lu	*II*	68.40	Gd	*I*	**09.94**	N	*I*	96.3	S	*I*	6902.46	F	*I*
84.00	V	*I*	92.965	Ni	*I*	74.33	Yt	*II*	23.23	La	*II*	4704.83	Br	*II*	65.430	A	*I*
85.406	V	*I*	96.208	Zr	*II*	75.73	Tl	*I*	23.85	Cb	*I*	10.075	Zr	*I*	7067.217	A	*I*
94.95	Cb	*II*	**98.95**	Ru	*I*	82.20	Os	*I*	29.72	Eu	*II*	**30.9**	Se	*I*	7503.868	A	*I*
3220.79	Ir	*I*	99.12	Er	*I*	88.69	Yt	*II*	37.13	Cb	*I*	39.1	Se	*I*	**7664.94**	K	*I*
25.47	Cb	*II*	3509.18	Tb	*I*	**98.26**	Mo	*I*	65.61	Ce	*II*	39.477	Zr	*I*	99.01	K	*I*
32.52	Sb	*I*	13.67	Ir	*I*	**3814.44**	Ra	*II*	67.99	Dy	*I*	42.3	Se	*I*	7771.97	O	*I*
32.67	Li	*I*	15.057	Ni	*I*	29.36	Mg	*I*	**72.05**	Ga	*I*	72.313	Zr	*I*	74.01	O	*I*
47.548	Cu	*I*	16.95	Pd	*I*	32.31	Mg	*I*	77.34	Nd	*I*	85.48	Br	*II*	75.68	O	*I*
62.30	Os	*I*	**19.605**	Zr	*I*	38.29	Mg	*I*	79.43	Pr	*I*	94.5	Cl	*I*	**7800.30**	Rb	*I*
62.33	Sn	*I*	24.543	Ni	*I*	48.76	Tb	*I*	86.60	Ce	*II*	4810.0	Cl	*I*	7947.63	Rb	*I*
67.48	Sb	*I*	29.814	Co	*I*	64.12	Mo	*I*	89.52	Pr	*I*	15.62	Zr	*I*	8115.308	A	*I*
67.94	Os	*I*	38.75	Th	*I*	74.19	Tb	*I*	4201.81	Rb	*I*	16.72	Br	*II*	**8521.15**	Cs	*I*
69.49	Ge	*I*	47.691	Zr	*I*	**88.64**	He	*I*	05.03	Eu	*I*	19.4	Cl	*I*	8943.6	Cs	*I*
73.964	Cu	*I*	52.20	U	*I*	91.02	Ho	*I*	11.74	Dy	*I*	**25.94**	Ra	*I*	9212.8	S	*I*
80.67	Ag	*I*	54.43	Lu	*II*	3902.96	Mo	*I*	15.515	Sr	*II*	32.07	Sr	*I*	28.2	S	*I*
82.32	Zn	*I*	61.75	Tb	*I*	05.52	Si	*I*	15.58	Rb	*I*	61.33	H	*I*	37.7	S	*I*
89.37	Yb	*I*	72.472	Zr	*II*	06.34	Er	*I*	25.34	Pr	*I*	72.48	Sr	*I*			

BIBLIOGRAPHY OF ABSORPTION SPECTRA OF SOLUTIONS

EMMA P. CARR AND MARY L. SHERRILL

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ABBREVIATIONS, SIGNS, SYMBOLS AND FORMS

All literature referred to contains an absorption curve of the substance in question unless otherwise indicated.

† The article contains some description of the absorption but no curve.

‡ The article contains either numerical data or a curve based on quantitative measurement of the extinction coefficients.

EtOH, Et_2O, alk., etc. Abbreviations for solvents in which the determinations were made.

EtOH + HCl The solvent is a mixture of the two ingredients indicated.

EtOH, (+HCl), (+alk.), etc. The solvents are ethyl alcohol, EtOH + HCl, and EtOH + alkalies (as NaOH, KOH, etc.).

P The absorption measurements are made of the pure substance in the liquid state.

Vap. The absorption measurements are made in the vapor state.

ABRÉVIATIONS, SIGNES, SYMBOLES ET FORMES

Toutes les sources bibliographiques mentionnées, contiennent une courbe d'absorption de la substance en question, à moins d'une autre indication.

† L'article contient une description de l'absorption mais aucune courbe.

‡ L'article contient ou des données numériques ou une courbe basée sur la mesure quantitative des coefficients d'extinction.

EtOH, Et_2O, alk., etc. Abréviations pour les solvants dans lesquels les déterminations ont été faites.

EtOH + HCl Le solvant est un mélange des deux substances indiquées.

EtOH, (+HCl), (+alk.), etc. Les solvants sont l'alcool éthylique, EtOH + HCl, et EtOH + alcalis (comme NaOH, KOH, etc.).

P Les mesures d'absorption ont été faites pour la substance pure à l'état liquide.

Vap. Les mesures d'absorption ont été faites pour la substance à l'état de vapeur.

ABKÜRZUNGEN, ZEICHEN, SYMBOLE UND FORMEN

Sämtlich hier angegebene Literatur enthält eine Absorptionskurve der in Frage stehenden Substanz, ausser es ist etwas anderes angegeben.

† Der Abschnitt enthält einige Angaben über die Absorption aber keine Kurve.

‡ Der Abschnitt enthält entweder numerische Daten oder eine Kurve, die sich auf Grund quantitativer Messungen des Extinktionskoeffizienten ergeben.

EtOH, Et_2O, alk., etc. Abkürzungen für die Lösungsmitteln in welchen die Messungen ausgeführt worden sind.

EtOH + HCl Das Lösungsmittel ist eine Mischung der zwei angegebenen Komponenten.

EtOH, (+HCl), (+alk.), etc. Die Lösungsmitteln sind Äthylalkohol, EtOH + HCl und EtOH + Alkalien (wie NaOH, KOH, u. s. w.).

P Die Absorptionsmessungen sind an reinen Stoffen in flüssigem Zustande gemacht worden.

Vap. Die Absorptionsmessungen sind an Stoffen im gasförmigen Zustande ausgeführt worden.

ABBREVIAZIONI, SEGNI, SIMBOLI E FORMULE

Tutte le pubblicazioni alle quali ci si riferisce contengono una curva di assorbimento della sostanza in questione a meno che non venga altrimenti indicato.

† L'articolo contiene qualche indicazione sopra l'assorbimento ma non contiene curve.

‡ L'articolo contiene valori numerici oppure una curva basata su misure quantitative dei coefficienti di estinzione.

EtOH, Et_2O, alk., etc. Abbreviazione per solventi nei quali furono fatte le determinazioni.

EtOH + HCl Il solvente è una miscela delle due sostanze indicate.

EtOH, (+HCl), (+alk.), etc. I solventi sono alcool etilico, EtOH + HCl, e EtOH + alcali (come NaOH, KOH, etc.).

P Le misure degli assorbimenti si riferiscono alla sostanza pura allo stato liquido.

Vap. Le misure dell'assorbimento si riferiscono allo stato di vapore.

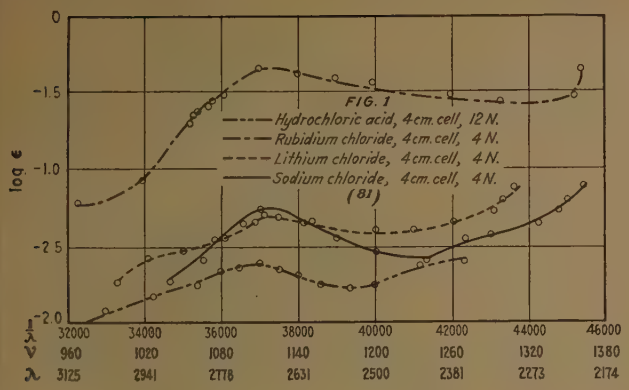
ABSORPTION SPECTRA OF SOLUTIONS OF INORGANIC COMPOUNDS EXCEPT THE SALT-DERIVATIVES OF ORGANIC COMPOUNDS

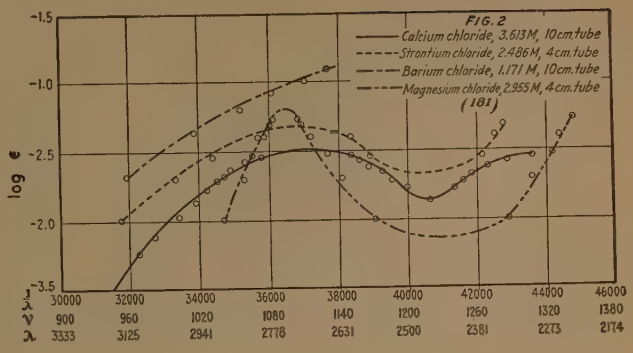
Scope.—Complete literature references are given for absorption measurements of solutions of inorganic substances in the infra-red region. For the visible and ultra-violet region an index is given below to the numerical data, and literature references for work published since 1910 except that of H. C. Jones and his collaborators who have examined the absorption spectra of several hundred inorganic substances in solution. The results of their work have been collected elsewhere (341.5, 343, 343.5, 344, 345) and are supplementary to this report.

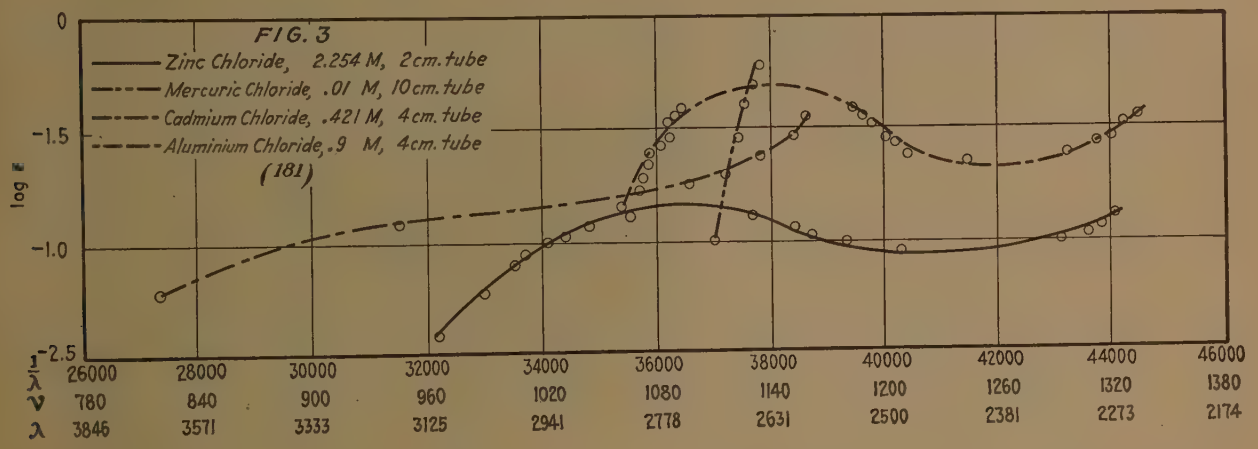
TABLE A-B.—STANDARD ARRANGEMENT
(*v.* Vol. III, p. viii)
The solvent is water unless otherwise stated

Formula	Solvents and literature
	Infra-red
HCl	(1,† 91)
I	CCl_4 (169†); EtOH, CS_2 (99)
H_2SO_4	(1,† 103, 489)
NH_3	(1,† 169,† 200)
HNO_3	(1,† 489)
NH_4NO_3	(107, 207,† 343,† 489)
NH_4Cl	(207,† 343†)
NH_4Br	(344)
$(NH_4)_2SO_4$	(169†)
$SiHCl_3$	(347‡)
$ZnSO_4$	(107, 344, 582)
$Zn(NO_3)_2$	(107, 344, 582)
$CuCl_2$	(50,† 107, 166,† 326†)
$CuBr_2$	(326†)
$CuSO_4$	(50,† 53,† 78,† 166,† 452,‡ 489†); *cf.* Fig. 5
$CuSO_4.4NH_3.H_2O$	(50†)
$Cu(C_2H_3O_2)_2$	(50†)
$AgNO_3$	(107)
CoF_2	(326‡)
$CoCl_2$	(106, 326‡); MeOH, EtOH, PrOH (345‡)
$CoBr_2$	(326‡)
CoI_2	(326‡)
$CoSO_4$	(326,‡ 345,‡ 489†)
$Co(NO_3)_2$	(326,‡ 345,‡ 489†)
Co salts	(78†)
$NiCl_2$	(326†); MeOH, EtOH, PrOH (345‡)
$NiBr_2$	(326†)
$NiSO_4$	(106, 345,‡ 489†)
$Ni(NO_3)_2$	(50,† 106, 345‡)
$NiCl_2.6NH_3$	(345‡)
$Ni(C_2H_3O_2)_2$	(106†)
Ni salts	(78†)
$CrCl_3$	(345‡)
$Cr_2(SO_4)_3$	(106, 345‡)
$Cr(NO_3)_3$	(345‡)
UCl_4	(50†)
$AlCl_3$	(107)
$Al_2(SO_4)_3$	(107, 169,† 207, 343)
$Al(NO_3)_3$	(107)
$Al_2(SO_4)_3.(NH_4)_2SO_4.24H_2O$	(103, 169†)
$FeCl_2$	(5)
$FeCl_3$	(5, 50,† 169,† 326)
$FeBr_3$	(5, 326)
$FeSO_4$	(5, 166†)
$Fe_2(SO_4)_3$	(5, 489†)
$Fe(NO_3)_3$	(5)
$Fe_2(SO_4)_3.(NH_4)_2SO_4.24H_2O$	(103, 345‡)
$Fe(C_2H_3O_2)_2$	(50†)
$ScCl_3$	With chlorides of Yb, Yt, La (103)
YCl_3	With chlorides of Sc, Yb, La (103)
$LaCl_3$	With chlorides of Sc, Yb, Yt (103)
$La(NO_3)_3$	(103)
$NdCl_3$	(342, 343); EtOH (344)
$NdBr_3$	(342)
$Nd_2(SO_4)_3$	(342)
$Nd(NO_3)_3$	(103, 342, 343)
$Nd(C_2H_3O_2)_3$	(342)
$(Pr, Nd)(NO_3)_3$	(103)
$YbCl_3$	With chlorides of Sc, Yt, La (103)
$MgCl_2$	(107, 207, 343, 344, 582)
$MgBr_2$	(344, 582)
$MgSO_4$	(344, 582)
$Mg(NO_3)_2$	(107); EtOH, Me_2CO (344)
$CaCl_2.2H_2O$	(207, 343, 344, 582)
$SrCl_2$	(107)
LiOH	(107, 200)
NaOH	(107, 200)
NaCl	(107, 166,† 347‡)
$Na_2S_2O_3$	(107)
$NaNO_3$	(344)
$Na_2O.SiO_2$	(103, 489)
$Na_2B_4O_7$	(103)
KOH	(107, 200†)
KCl	(91, 207,† 343,† 344,† 582†)
KNO_3	(343,† 489†)
$KMnO_4$	(103, 345‡)
$K_3Fe(CN)_6$	(50†)
$K_4Fe(CN)_6$	(50†)
$K_2Ni(SO_4)_2$	(50†)
K_2CrO_4	(50,† 53†)
$K_2Cr_2O_7$	(50,† 166†)
$Cr_2(SO_4)_3.K_2SO_4.24H_2O$	(50,† 106†)
$KCr(C_2O_4)_2$	(166†)
$Al_2(SO_4)_3.K_2SO_4.24H_2O$	(103, 148,† 169†)
CsOH	(200)
	Ultra-violet and Visible
H_2O_2	(552)
HCl	(81‡); *cf.* Fig. 1
HClO	(562, 568)
HBrO	(568)
$HBrO_3$	(568, 660)
I	(176.2); CCl_4 (83.2, 94, 612); CS_2, Ac_2O, PhMe, $C_6H_4Me_2$ (485); $CHCl_3$ (94, 116, 387, 485, 612, 646); MeOH, H_2O (612); EtOH (83.2, 94, 116, 386, 387, 485, 611, 612); PrOH, *iso*-PrOH, *sec.*-BuOH, NaOH (623); AcEt (646); C_6H_6 (94, 485, 646); C_6H_{14} (116, 387, 646); H_2O + KI (83.2); Et_2O (116, 387)
HIO_3	(182, 568, 660†)
S	CCl_4, CS_2, C_6H_6 (654)
H_2S	(659, 660†)
H_2SO_3	(19,‡ 174,‡ 182,‡ 562, 567, 660, 661); *cf.* Fig. 7
H_2SO_4	(471.5‡); metallic salts: (114†)
HNO_2	(182,‡ 660)

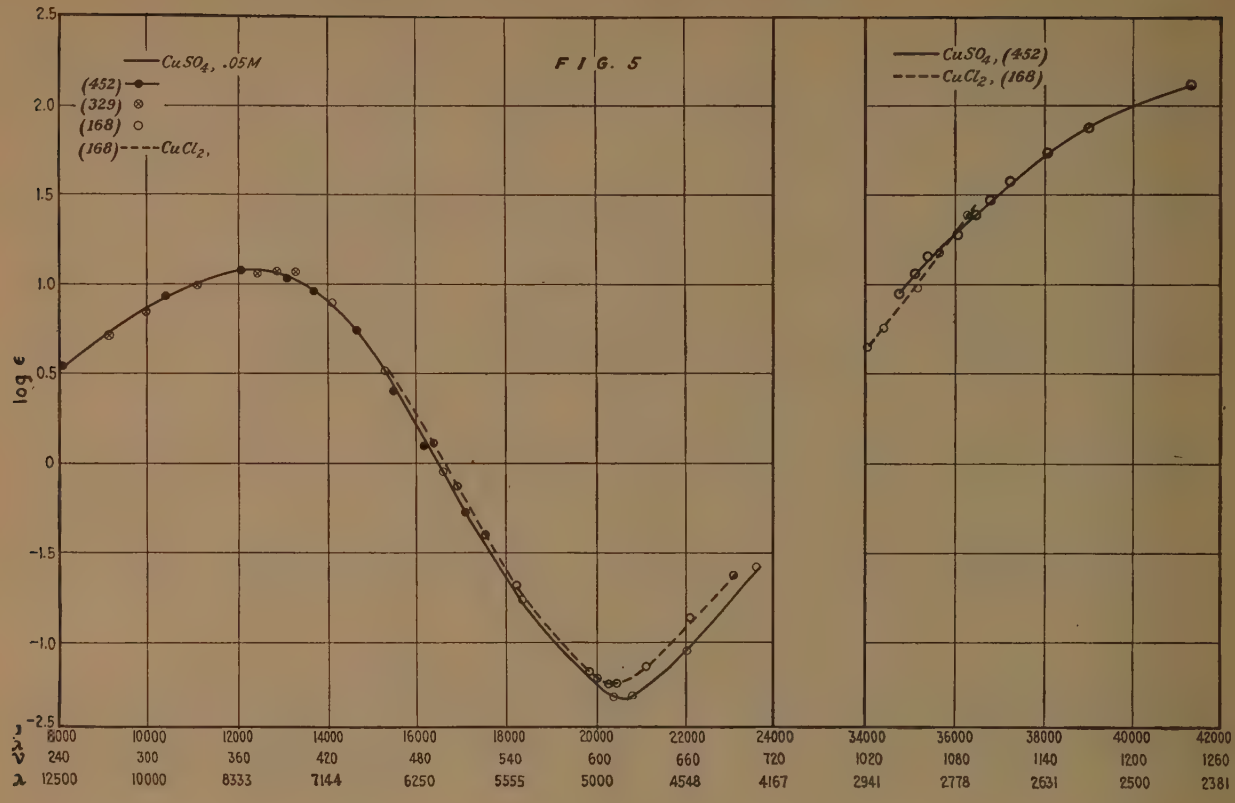
Formula	Solvents and literature
Ultra-violet and Visible.—(*Continued*)	
HNO_3	(182‡); P (564); H_2O (562, 563, 564); Et_2O (562, 563, 564); EtOH (562, 563); Vap. (564)
NH_2OH	(25†)
NH_2NO_2	EtOH (25)
NH_4NO_3	(561)
$NH_2OH.HCl$	H_2O (276†)
NH_4Br	(81‡)
$NO_2.SO_3H$	H_2SO_4 (25)
$HONO.SO_3H$	(25†)
$NH_2.SO_3H$	H_2O (25)
$NH_4.HSO_3$	(174)
H_3AsO_3	(182,‡ 659, 660†)
H_3AsO_4	(182‡)
$AsCl_3$	(422‡)
As_2S_5	(79†)
$SbCl_3$	(422‡)
Sb (complex salts)	(407)
$BiCl_3$	(422‡); in various solvents (569)
$Bi(ClO_4)_3$	(566, 569)
$BiBr_3$	H_2O, (+HBr), Et_2O (569)
$Bi_2(SO_4)_3$	H_2SO_4 (569)
$Bi(NO_3)_3$	(566)
Bi (complex salts)	(569)
$Si(C_6H_5)_4$	$CHCl_3$ (522)
$Si(OH)_2(C_6H_5CH_2)_2$	EtOH, (+alk.) (551)
$[SiOH(C_6H_5CH_2)_2]_2O$	EtOH (551)
$[SiO(C_6H_5CH_2)_2]_3$	$CHCl_3$ (551)
$Si_3(OH)_2[(C_6H_5CH_2)_2]_3O_2$	EtOH (551)
Ge	(485.5†)
Sn (complex salts)	(587, 588)
$Pb(NO_3)_2$	(272, 561)
$Th(NO_3)_4$	(272,† 561, 566)
$ThCl_4$	(272†)
Tl_2SO_4	(272†)
$TlNO_3$	(272,† 566)
$ZnCl_2$	(181‡); *cf.* Fig. 3
Zn (complex salts)	(587, 588)
$CdCl_2$	(181‡); *cf.* Fig. 3
Cd (complex salts)	(587, 588)
Hg	(176.2†)
$HgCl_2$	(113, 181,‡ 390); *cf.* Fig. 3
$Hg(ClO_4)_2$	(390)
$HgBr_2$	(113, 390)
HgI_2	(113, 390)
$HgNO_3$	(113, 562, 566)
$Hg(NO_3)_2$	(113)
$Hg(CH_3)_2$	Et_2O (113)
$Hg(C_2H_5)_2$	EtOH (113)
$Hg(C_6H_5)_2$	EtOH (386); $CHCl_3$ (537)
$Hg(C_6H_5CH_2)_2$	$CHCl_3$ (537)
$HgCH_3Cl$	(390); EtOH (113)
HgC_2H_5Cl	(390); EtOH (113)
$HgCH_3Br$	EtOH (113)
$HgCH_3I$	EtOH (113)
HgC_2H_5I	EtOH (113)
$HgN(CH_2CO)_2OH$	(390)
$Hg(C_3H_5ONH)_2$	(390)
Hg (complex salts)	(113, 341, 587)
$CuCl_2$	(87,† 110, 178,‡ 179, 181‡); EtOH, Me_2CO (332); *cf.* Fig. 5
$Cu(ClO_4)_2$	(221)
$CuBr_2$	(87†); EtOH, Me_2CO (332)
$CuSO_4$	(87,† 221, 452‡); *cf.* Fig. 5
$Cu(NO_3)_2$	(163, 561, 566); EtOH, Me_2CO (332); *cf.* Fig. 6
$Cu(NO_3)_2.6NH_3$	(163)
$CuCl_2.6NH_3$	(488)
$Cu(HONO.SO_3)$	H_2SO_4 (25)
Cu salts	H_2O, EtOH, $CHCl_3$ (168)
Cu (complex salts)	(87,† 587, 589, 590)
Ag_2SO_4	(272†)
$AgNO_3$	(272,† 561, 562, 566, 657‡)
Ag (complex salts)	(587, 588)
Au sols	(49.5, 483‡)
Ir (complex salts)	(4, 408)
H_2PtCl_6	H_2O, EtOH (221, 230)
$CuPtCl_6.18NH_3$	(488)
Pt (complex salts)	(408, 587, 588)
Rh (complex salts)	(408)
$MnCl_2$	(340)
$MnCl_3$	(340)
$MnCl_4$	(340)
$MnSO_4$	(340)
$Mn_2(SO_4)_3$	(340)
$Mn(NO_3)_3$	(561)
$Zn(MnO_4)_2$	(458, 503)
Mn (complex salts)	(407)
Fe (complex salts)	(88, 407, 408)
CoF_2	(320, 328, 330)
$CoCl_2$	(330); EtOH (110, 227, 332); Me_2CO (332); H_2O (110); MeOH (408)
$CoBr_2$	(110, 328, 330); EtOH, Me_2CO (332)
CoI_2	(328, 330)
$CoSO_4$	(320, 328, 330)
$Co(NO_3)_2$	(162, 320, 328, 330, 460,‡ 561); EtOH, Me_2CO (332)
Co (complex salts)	(407, 408, 420, 444, 470, 492, 585, 586, 591, 643); $CHCl_3$ (123†)
$NiCl_2$	(327,‡ 328,‡); EtOH, Me_2CO (332‡)
$NiBr_2$	(327,‡ 328,‡ 332‡)
NiI_2	(327,‡ 328‡)
$NiSO_4$	(327,‡ 328‡)
$Ni(NO_3)_2$	(164, 327,‡ 328,‡ 332,‡ 561)
$Ni(CO)_4$	(408)
Ni (complex salts)	(470, 589, 590)
H_2CrO_4	(221)
$Cr_2(SO_4)_3$	(197)
Cr (complex salts)	(88, 167, 407, 589, 590)
UCl_2	Various solvents (459,† 461†)
USO_4	Various org. solvents (459†)
U (complex salts)	(449,† 450,† 451)
$AlCl_3$	(179‡); *cf.* Fig. 3
Al (complex salts)	(588)
$Ce(NO_3)_3$	(566)
$PrCl_3$	(4, 15,† 48,† 321,† 662)
$Pr_2(SO_4)_3$	(15†)
$Pr(NO_3)_3$	(15,† 321†)
$NdCl_3$	(4,† 15,† 47,† 49,† 110, 173,† 321, 596,† 662)
$Nd_2(SO_4)_3$	(15)
$Nd(NO_3)_3$	(15, 47,† 321†)
Di salts	(4,† 529†)
$SaCl_3$	(662)
$Sa(NO_3)_3$	(499†)

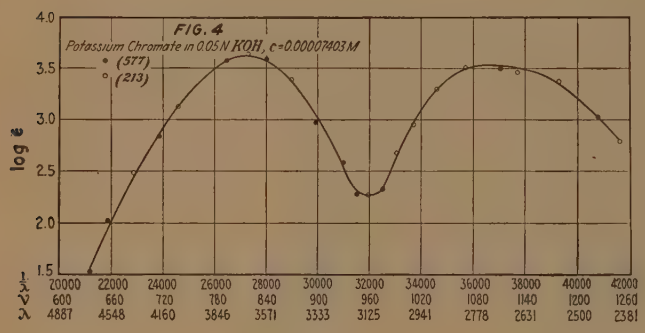


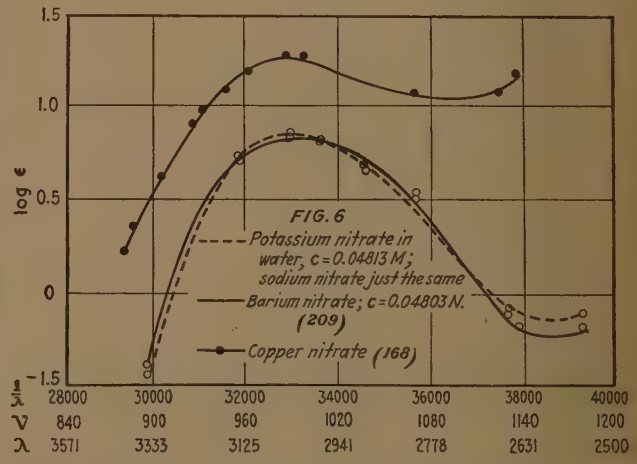


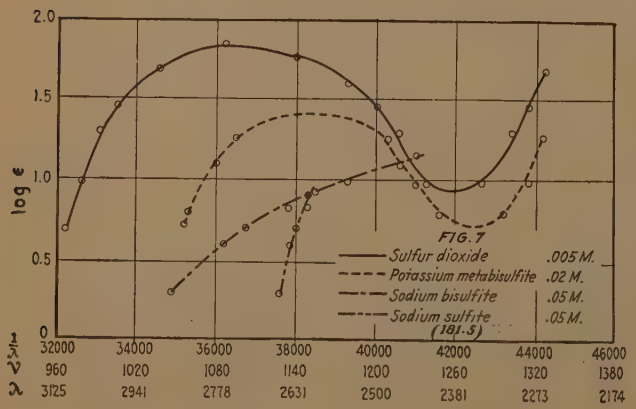


Formula	Solvents and literature
Ultra-violet and Visible.—(*Continued*)	
$Eu(NO_3)_3$	(498, 499)
$DyCl_3$	(662)
$HoCl_3$	(662)
$Ho(NO_3)_3$	(322†)
$ErCl_3$	(662)
$TmCl_3$	(662)
$Be(NO_3)_2$	(566)
Mg	$MeNH_2$ (188‡); liq. NH_3 (187,‡ 188‡)
$MgCl_2$	(181,‡ 495‡); *cf.* Fig. 2
$Mg(NO_3)_2$	EtOH (563)
Ca	$MeNH_2$, liq. NH_3 (188‡)
$CaCl_2$	(181,‡ 495‡); *cf.* Fig. 2
$Ca(NO_3)_2$	(561); EtOH, H_2O (240)
$Ca(MnO_4)_2$	(2†); H_2O, Me_2CO, MeOH, C_5H_5N, Me_2CNOH, EtOH (458†)
$Ca_2Fe(CN)_6$	(230)
$SrCl_2$	(181,‡ 495‡); *cf.* Fig. 2
$Sr(NO_3)_2$	(561)
$BaCl_2$	(181,‡ 495‡); *cf.* Fig. 2
$Ba(NO_3)_2$	(182,‡ 209,‡ 561); *cf.* Fig. 6
$Ba(MnO_4)_2$	(503); H_2O, various solvents (458)
Li	$MeNH_2$, liq. NH_3 (188‡)
LiCl	(81,‡ 544); *cf.* Fig. 1
LiBr	(544)
LiI	(81‡)
$LiNO_3$	(561)
Na	$MeNH_2$ (188‡); liq. NH_3 (187,‡ 188‡)
NaCl	(81,‡ 544); *cf.* Fig. 1
NaClO	(380,† 562, 568)
$NaClO_2$	(568)
NaBr	(81,‡ 544)
NaBrO	(568)
$NaBrO_3$	(568, 660†)
NaI	(81,‡ 544)
$NaIO_3$	(568, 660†)
Na_2S	(659, 660†)
Na_2SO_3	(19,‡ 182,‡ 562, 660, 661); H_2O, H_2SO_4 (567); *cf.* Fig. 7
NaHS	(660†)
$NaHSO_3$	(174,‡ 182,‡ 562, 567, 660); *cf.* Fig. 7
$NaNO_2$	(113, 660)
$NaNO_3$	(113, 182,‡ 209,‡ 561, 562, 563); *cf.* Fig. 6
$(NaON)_2O$	H_2O (25)
Na_3AsO_3	(659, 660†)
Na_3AsO_4	(182‡)
NaH_2AsO_3	(659,† 660†)
Na_2HAsO_3	(659,† 660†)
Na_2PtCl_6	(221, 230)
$Na_4Fe(CN)_6$	(230)









Formula	Solvents and literature
Ultra-violet and Visible.—(*Continued*)	
K	$MeNH_2$, liq. NH_3 (188‡)
KOH	(471.5‡)
KBr	(81‡); H_2O + $Na_2S_2O_3$ (83.2)
KI	(81,‡ 544); H_2O + $Na_2S_2O_3$ (83.2)
KIO_3	(182‡)
K_2SO_4	(471.5‡)
$K_2S_2O_5$	(19,‡ 567); *cf.* Fig. 7
$K_2S_2O_8$	H_2O, H_2SO_4 (471.5‡)
$KHSO_3$	(19,‡ 174‡)

Formula	Solvents and literature
Ultra-violet and Visible.—(*Continued*)	
KNO_2	(182‡)
KNO_3	(182,‡ 209,‡ 561, 562, 563, 565, 625, 657); *cf.* Fig. 6
$(KSO_3)_2NO$	H_2O (25)
$(KSO_3)_2NOH$	H_2O (25)
K_3AsO_3	(182‡)
K_2PtF_6	(580)
K_2PtCl_4	(408)
K_2PtCl_6	(221, 408, 580)
K_2PtBr_6	(580)
K_2PtI_6	(580)
$KMnO_4$	(2, 3, 193, 208,‡ 340, 503, 547, 645‡); H_2SO_4, MeOH, Me_2CO, AcOH, C_5H_5N, KOH (228); various solvents (458)
K_2MnO_4	(340)
$KCo(NH_3)_2(NO_2)_4$	H_2O, MeOH, C_5H_5N (221)
$K_2Co(CNS)_4$	(227)
$K_3Co(CN)_6$	(407, 588)
K_2CrO_4	(221, 574‡); KOH (213‡); *cf.* Fig. 4
$K_2Cr_2O_7$	(221)
$K_3Cr(CN)_6$	(407)
$K_3Fe(CN)_6$	(177, 407, 492)
$K_4Fe(CN)_6$	(177, 221, 230, 492, 588)
RbCl	(81‡); *cf.* Fig. 1
RbI	(81‡)
$RbHSO_3$	(174‡)
Cs	$MeNH_2$ (188‡)
CsI	(81‡)

ORGANIC COMPOUNDS AND THEIR INORGANIC SALT-DERIVATIVES

Scope.—The following bibliographic index serves also as an index to the numerical data, given as curves, on p. 359–379. The bibliography includes all organic substances, exclusive of dyes, whose absorption spectra have been measured. In the infra-red region all measurements are quantitative; in the ultra-violet a very large proportion are purely qualitative and are based on the change of the limits of absorption with the length of the path.

Arrangement.—The organic compounds are arranged according to the "ℭ-arrangement" and their inorganic salt-derivatives are grouped immediately after the parent compound. Substances to which a formula cannot be assigned are listed at the end of each section (p. 334 and p. 356).

For reference texts, *see* (297, 348). The solvent is ethyl alcohol unless otherwise stated.

ℭ-Table.—ℭ-Arrangement

(*v.* Vol. III, p. viii)

Formula	Name, solvents and literature
Infra-red	
CCl_2O	Phosgene (437)
CCl_2S	Thiophosgene (437†)
CCl_4	Carbon tetrachloride (101, 126,† 169,† 336,† 347,‡ 501†)
COS	Carbonyl sulfide (346)
CS_2	Carbon disulfide (6, 7, 12, 101, 126,† 169,† 336,† 347,‡ 501,† 555†); Vap. (6,† 7, 9, 12, 556,† 557†)
$CHBr_3$	Bromoform (152, 169,† 336,† 347‡)
$CHCl_3$	Chloroform (1,† 52.4, 101, 149, 151,† 152, 169,† 336,† 347,‡ 437, 627); Vap. (126,‡ 149, 373†)
CHI_3	Iodoform (101)
CHN	Hydrogen cyanide (46, 85, 313†); Vap. (85)
CH_2Br_2	Methylene bromide (152)
CH_2Cl_2	Methylene chloride (152, 169,† 336†)
CH_2I_2	Methylene iodide (152, 169,† 336†)
CH_2O_2	Formic acid (1†); Vap. (373†)
CH_3Cl	Methyl chloride: Vap. (556,† 557†)
CH_3I	Methyl iodide (1,† 100,† 101, 152, 169,† 336,† 501,† 502)
CH_3NO_2	Nitromethane (101)
CH_4	Methane: Vap. (6,† 7, 10,† 11, 100,† 101, 108,† 109,† 124,† 125,† 126,† 313,† 541,† 556,† 557†)
CH_4O	Methyl alcohol (1,† 8, 73,‡ 169,† 345,‡ 347,‡ 375,† 376,† 377,† 501,† 502,† 652); Vap. (10,† 373†)
C_2Cl_4	Tetrachloroethylene (101, 169†)
$(CN)_2$	Cyanogen: Vap. (85, 556,† 557†)
C_2HCl_3	Trichloroethylene (592.2)
$C_2HCl_3O_2$	Trichloroacetic acid (52.4)
C_2H_2	Acetylene: Vap. (6,† 9,† 85, 100,† 101, 126,† 313,† 349,† 376,† 556,† 557†)
$C_2H_2Cl_2$	Dichloroethylene (592.2)
$C_2H_2Cl_2O_2$	Dichloroacetic acid (52.4)
$C_2H_2Cl_4$	Tetrachloroethane (592.2, 627)
$C_2H_3ClO_2$	Chloroacetic acid (52.4)
$C_2H_3Cl_3O_2$	Chloral hydrate (102)
C_2H_3N	Acetonitrile (101)
C_2H_3NS	Methyl isothiocyanate (100, 101
C_2H_4	Ethylene (7, 9,† 100, 101, 126,† 313,† 349, 436, 556, 557†)
$C_2H_4Br_2$	Ethylene bromide (101, 152, 169†)
$C_2H_4Cl_2$	Ethylene chloride (152, 169,† 336,† 592.2)
$C_2H_4Cl_2$	1, 1-Dichloroethane (336†)
C_2H_4O	Acetaldehyde (1,† 169,† 376,† 652)
$C_2H_4O_2$	Acetic acid (1,† 52.4, 101)
C_2H_5Br	Ethyl bromide (1,† 152, 169,† 336†)
C_2H_5Cl	Ethyl chloride (152)
C_2H_5I	Ethyl iodide (1,† 100,† 101, 152, 169,† 336,† 502†); Vap. (349†)
$C_2H_5NO_2$	Nitroethane (101)
$C_2H_5NO_3$	Ethyl nitrate (1†)
C_2H_6	Ethane (100,† 101, 313, 375†)
C_2H_6O	Ethyl alcohol (1,† 8, 73,‡ 101, 169,† 336,† 345,‡ 347,‡ 377,† 417, 501,† 555,† 558,† 592.2, 652, 653†); Vap. (373,† 556,† 557,† 558†); Na salt (652)
C_2H_6O	Methyl ether (101, 501,†); Vap. (9,† 100,† 313)
$C_2H_6O_2$	Glycol (169,† 652)
C_2H_6S	Ethylmercaptan (101, 347‡)
C_2H_7N	Ethylamine (169†)
$C_2H_8N_2$	Ethylenediamine (169†)
C_3H_4O	Acrolein (437†)
C_3H_5Br	Allyl bromide (169†)
C_3H_5Cl	Allyl chloride (169†)
C_3H_5I	Allyl iodide (169†)
C_3H_5N	Ethyl cyanide (101)
C_3H_5NS	Ethyl isothiocyanate (100, 101†)
$C_3H_6Br_2$	Trimethylene bromide (169†)
C_3H_6O	Allyl alcohol (1,† 501,† 652)
C_3H_6O	Propionaldehyde (378,† 437)
C_3H_6O	Acetone (101, 152, 169,† 374,† 375,† 376,† 378,† 437, 627); Vap. (101)
$C_3H_6O_2$	Propionic acid (1†)
$C_3H_6O_2$	Methyl acetate (52.4, 91, 101, 169,† 366,† 376,† 592.2, 652); Vap. (349†)
$C_3H_6O_3$	Methyl carbonate (101)
C_3H_7Br	Propyl bromide (152)
C_3H_7I	Propyl iodide (1,† 152)

Formula	Name, solvents and literature
	Infra-red.—(*Continued*)
C_3H_7I	Isopropyl iodide (152)
C_3H_8O	Isopropyl alcohol (1,† 377, 652)
C_3H_8O	Propyl alcohol (1,† 73,‡ 169,† 345,‡ 347,‡ 377,† 627, 652)
$C_3H_8O_2$	Propyleneglycol (652)
$C_3H_8O_3$	Glycerol (1,† 101, 105, 169, 489, 652)
C_3H_9N	*n*-Propylamine (52.3, 153.3)
$C_3H_{12}N_6O_3$	Guanidine carbonate (570)
C_4H_4S	Thiophene (101)
C_4H_5N	Pyrrole (100, 101)
C_4H_5NS	Allyl isothiocyanate (100,† 101)
$C_4H_6O_3$	Acetic anhydride (52.4, 169†)
$C_4H_6O_5$	Malic acid (102)
C_4H_8O	Butyraldehyde (378,† 437†)
C_4H_8O	Isobutyraldehyde (437†)
C_4H_8O	Ethyl methyl ketone (378†)
$C_4H_8O_2$	Butyric acid (652)
$C_4H_8O_2$	Isobutyric acid (1, 652)
$C_4H_8O_2$	Ethyl acetate (169,† 652)
$C_4H_8O_2$	Methyl propionate (652)
C_4H_9Br	Isobutyl bromide (152)
C_4H_9Cl	Isobutyl chloride (152)
C_4H_9I	Isobutyl iodide (152)
$C_4H_9NO_2$	Butyl nitrite (152)
C_4H_{10}	Butane (100, 101,† 349†)
$C_4H_{10}O$	Methyl *n*-(iso)propyl ether (592.2)
$C_4H_{10}O$	Butyl alcohol (1,† 73,‡ 347,‡ 375,† 377,† 592.2, 652); Vap. (373†)
$C_4H_{10}O$	Isobutyl alcohol (1,† 169,† 336,† 345,‡ 347,‡ 375,† 377,† 652)
$C_4H_{10}O$	*sec.*-Butyl alcohol (652)
$C_4H_{10}O$	*tert.*-Butyl alcohol (377†)
$C_4H_{10}O$	Ethyl ether (1,† 101, 152, 169,† 336,† 347,‡ 373, 555,† 592.2); Vap. (6,† 7, 9,† 11, 12, 100,† 373, 556,† 557,† 558†)
$C_4H_{10}O_3$	Methylglycerol (377†)
$C_4H_{10}O_4S$	Ethyl sulfate (101)
$C_4H_{10}S$	Ethyl sulfide (1,† 101)
$C_4H_{11}N$	Diethylamine (169†)
$C_4H_{11}N$	*n*-Butylamine (52.3, 153.3)
$C_5H_4O_3$	Citraconic anhydride (1†)
C_5H_5N	Pyridine (100, 101, 501,† 595)
C_5H_8O	Allyl methyl ketone (378†)
C_5H_8O	Ethyl propargyl ether (374†)
$C_5H_8O_2$	Acetylacetone (376†)
$C_5H_8O_4$	Dimethyl malonate (375†)
$C_5H_{10}O$	Isovaleric aldehyde (378†)
$C_5H_{10}O$	Diethyl ketone (378†)
$C_5H_{10}O$	Isopropyl methyl ketone (378†)
$C_5H_{10}O_2$	Valeric acid (1,† 101)
$C_5H_{10}O_2$	Butyl formate (375†)
$C_5H_{10}O_2$	Isobutyl formate (375†)
$C_5H_{10}O_2$	*n*-Propyl acetate (592.2)
$C_5H_{10}O_2$	Ethyl propionate (592.2, 652)
$C_5H_{10}O_2$	Methyl butyrate (652)
$C_5H_{10}O_2$	Methyl isobutyrate (652)
$C_5H_{10}O_3$	Ethyl lactate (592.2)
$C_5H_{10}O_3$	Ethyl carbonate (101, 592.2)
$C_5H_{11}Br$	Amyl bromide (1,† 169†)
$C_5H_{11}Cl$	Amyl chloride (169†)
$C_5H_{11}I$	Amyl iodide (1,† 169†)
$C_5H_{11}N$	Piperidine (100, 101, 595)
$C_5H_{11}NO_2$	Amyl nitrite (1†)

Formula	Name, solvents and literature
C_5H_{12}	Pentane (152, 153); Vap. (556,† 557†)
$C_5H_{12}O$	Amyl alcohol (1,† 101, 169,† 347,‡ 627, 652); Vap. (373)
$C_5H_{12}O$	Isoamyl alcohol (345,‡ 377,† 652)
$C_5H_{12}O$	*tert.*-Amyl alcohol (377,† 652)
$C_5H_{12}O$	Methyl iso(*n*-, *sec.*-, *tert.*-) butyl ether (592.2)
$C_5H_{12}O_3$	Ethylglycerol (377†)
$C_5H_{13}N$	Isoamylamine (52.3, 153.3)
C_6H_5Br	Bromobenzene (1,† 101, 528); Vap. (528)
C_6H_5Cl	Chlorobenzene (101,† 437, 528); Vap. (528)
C_6H_5F	Fluorobenzene (437)
C_6H_5I	Iodobenzene (528); Vap. (528)
$C_6H_5NO_2$	Nitrobenzene (1,† 101, 169,† 627)
C_6H_6	Benzene (1,† 52, 46.5,† 74, 100, 101, 105, 149, 152, 153.2, 169,† 347,‡ 376,† 436, 437, 501, 502, 528, 555†); Vap. (6,† 10,† 149, 373,† 528, 558†)
C_6H_6O	Phenol (100,† 101)
$C_6H_6O_3$	Phloroglucinol (102)
C_6H_7N	Aniline (1,† 51, 52.1,† 100, 101, 153.2, 153.3, 169,† 367, 436); Vap. (367)
C_6H_7N	*α*-Picoline (100, 101, 595)
$C_6H_{10}O_3$	Ethyl acetoacetate (1,† 376†)
$C_6H_{10}O_4$	Ethyl oxalate (1,† 375,† 376,† 652)
$C_6H_{10}O_4$	Methyl succinate (375†)
$C_6H_{10}S$	Allyl sulfide (1,† 101)
$C_6H_{11}I$	Hexyl iodide (1†)
$C_6H_{11}N$	Amyl cyanide (169†)
C_6H_{12}	Cyclohexane (374,† 376,† 437)
$C_6H_{12}O$	Isobutyl methyl ketone (73,‡ 378†)
$C_6H_{12}O_2$	Caproic acid (100,† 101)
$C_6H_{12}O_2$	Isocaproic acid (101)
$C_6H_{12}O_2$	Amyl formate (375,† 592.2)
$C_6H_{12}O_2$	Isoamyl formate (652)
$C_6H_{12}O_2$	Ethyl butyrate (375,† 592.2, 652)
$C_6H_{12}O_2$	Isobutyl acetate (652)
$C_6H_{12}O_2$	Methyl valerate (375†)
$C_6H_{12}O_2$	Methyl isovalerate (652)
$C_6H_{12}O_2$	Propyl propionate (375†)
$C_6H_{12}O_3$	Paraldehyde (1,† 101, 169†)
$C_6H_{12}O_6$	*d*-Fructose (102)
$C_6H_{12}O_6$	*d*-Glucose (102)
C_6H_{14}	Diisopropyl (169†)
C_6H_{14}	Hexane (73,‡ 101, 152, 169,† 347,‡ 437)
$C_6H_{14}O$	Methyldiethyl carbinol (592.2)
$C_6H_{14}O$	Methyl iso(*n*-, *tert.*-) amyl ether (592.2)
$C_6H_{14}O$	Hexyl alcohol (377†)
$C_6H_{14}O$	Methyl diethylcarbinyl ether (592.2)
$C_6H_{14}O_3$	Propylglycerol (377†)
$C_6H_{14}O_6$	Mannitol (102)
$C_6H_{15}BrS$	Triethylsulfonium bromide: $C_2H_2Cl_4$, $C_6H_5NO_2$, C_3H_7OH, $C_5H_{11}OH$, $PhCH_2OH$, Me_2CO (627)
$C_6H_{15}N$	Di-*n*-propylamine (52.3, 153.3)
$C_6H_{15}N$	Triethylamine (101)
C_7H_5N	Benzonitrile (101, 169†)
C_7H_5NS	Phenylisothiocyanate (100, 101)
C_7H_6O	Benzaldehyde (100,† 101, 169,† 378,† 436)
$C_7H_6O_2$	Benzoic acid (595)
C_7H_7Cl	Benzyl chloride (1,† 169†)
C_7H_7NO	*o*-(*p*-)Nitrotoluene (101)
C_7H_8	Toluene (8, 46.5,† 100, 101, 152, 169,† 436, 437, 501,† 502, 555†)
C_7H_8O	Benzyl alcohol (374,† 627)
C_7H_8O	Anisole (100, 101)
C_7H_9N	Benzylamine (52.2, 153.3)

Formula	Name, solvents and literature
	Infra-red.—(*Continued*)
C_7H_9N	Methylaniline (51, 101, 153.3)
C_7H_9N	*o*-Toluidine (101)
C_7H_9N	*p*-Toluidine (153.3, 436)
$C_7H_{12}O_4$	Diethyl malonate (375,† 376,† 652)
$C_7H_{12}O_4$	Dimethyl glutarate (375†)
C_7H_{14}	Dimethylcyclopentane (101†)
C_7H_{14}	Methylcyclohexane (437)
$C_7H_{14}O$	Heptaldehyde (378†)
$C_7H_{14}O$	Dipropyl ketone (378†)
$C_7H_{14}O_2$	Amyl acetate (376,† 592.2)
$C_7H_{14}O_2$	Isoamyl acetate (652)
C_7H_{16}	Heptane (152, 153)
$C_7H_{16}O$	Heptyl alcohol (377†)
$C_7H_{16}O_3$	Butylglycerol (377†)
C_8H_6	Phenylacetylene (374†)
C_8H_8O	Acetophenone (378†)
$C_8H_8O_2$	Anisaldehyde (374,† 378†)
$C_8H_8O_2$	Phenyl acetate (101)
$C_8H_8O_2$	Methyl benzoate (592.2)
$C_8H_8O_3$	Methyl salicylate (1,† 100,† 101)
C_8H_{10}	Ethylbenzene (46.5,† 436, 501†)
C_8H_{10}	Xylene (169,† 555†)
C_8H_{10}	*o*-Xylene (46.5,† 100, 101, 436, 437,† 501,† 502)
C_8H_{10}	*m*-Xylene (46.5,† 101,† 153.2, 436, 437, 501†)
C_8H_{10}	*p*-Xylene (46.5,† 100,† 101, 152, 436, 437,† 501†)
$C_8H_{10}N_2O$	*p*-Nitrosodimethylaniline (101, 489)
$C_8H_{10}O_2$	Dimethylresorcinol (376†)
$C_8H_{11}N$	Dimethylaniline (1, 51, 101, 153.2)
$C_8H_{11}N$	Ethylaniline (51, 153.2)
$C_8H_{11}N$	Xylidine (100, 101)
$C_8H_{11}N$	Methyl-*p*-toluidine (153.3)
$C_8H_{14}O_4$	Diethyl succinate (101, 376,† 652)
C_8H_{16}	Dimethylcyclohexane (374,† 437)
$C_8H_{16}O$	Hexyl methyl ketone (378†)
$C_8H_{16}O$	Octyl aldehyde (378†)
$C_8H_{16}O_2$	Butyl butyrate (652)
$C_8H_{16}O_2$	Isoamyl propionate (652)
$C_8H_{17}N$	Coniine (595)
C_8H_{18}	Octane (100, 101, 152)
$C_8H_{18}O$	*n*-Octyl alcohol (376,† 377†)
$C_8H_{18}O$	*sec.*-Octyl alcohol (377†)
$C_8H_{18}O$	Butyl ether (152)
$C_8H_{18}O$	Octyl alcohol (652)
$C_8H_{18}O_2$	α-Dimethyl-β-isobutylglycol (377†)
$C_8H_{19}N$	Di-*n*-butylamine (52.3)
C_9H_7N	Quinoline (101, 595)
$C_9H_{10}O$	Ethyl phenyl ketone (378†)
$C_9H_{10}O_2$	Ethyl benzoate (1†)
C_9H_{12}	Cumene (101)
C_9H_{12}	Mesitylene (46.5,† 100,† 101, 152, 153, 436, 437†)
C_9H_{12}	Propylbenzene (374†)
$C_9H_{12}O$	Phenylpropyl alcohol (1†)
$C_9H_{12}O$	Benzyl ethyl ether (1†)
$C_9H_{13}N$	Methylethylaniline (51, 153.2)
$C_9H_{13}N$	Propylaniline (51, 153.2)
$C_9H_{13}N$	Dimethyl-*p*-toluidine (153.3)
C_9H_{14}	Cyclohexylpropine (374†)
$C_9H_{14}O_6$	Triacetin (374)
$C_9H_{16}ClNO_3$	Ecgonine hydrochloride (595)
$C_9H_{16}O_2$	Amyl crotonate (374,† 376†)
$C_9H_{16}O_4$	Diethyl glutarate (376†)
$C_9H_{16}O_4$	Dimethyl β-methyladipate (375†)
$C_9H_{18}O$	Nonyl aldehyde (378)

Formula	Name, solvents and literature
$C_9H_{18}O_2$	Isoamyl butyrate (652)
$C_9H_{18}O_2$	Isoamyl isobutyrate (652)
$C_9H_{20}O$	Nonyl alcohol (377†)
$C_9H_{21}N$	Tri-*n*-propylamine (52.3, 153.3)
$C_{10}H_7NO_2$	α-Nitronaphthalene (597)
$C_{10}H_8$	Naphthalene (52, 101, 436); CS_2, CCl_4 (597)
$C_{10}H_8O$	$\alpha(\beta)$-Naphthol: CCl_4, CS_2 (597)
$C_{10}H_9N$	$\alpha(\beta)$-Naphthylamine: CCl_4, CS_2 (153.3, 597)
$C_{10}H_{10}O_2$	Safrole (101)
$C_{10}H_{12}O$	Cumic aldehyde (101)
$C_{10}H_{12}O$	Anethole (1,† 374,† 376†)
$C_{10}H_{12}O$	Isopropyl phenyl ketone (375,† 378†)
$C_{10}H_{12}O$	Propyl phenyl ketone (375†)
$C_{10}H_{12}O_2$	Eugenol (100,† 101)
$C_{10}H_{14}$	Cymene (101, 436)
$C_{10}H_{14}$	Diethylbenzene (46.5†)
$C_{10}H_{14}O$	Thymol (100,† 101)
$C_{10}H_{14}O$	Carvacrol (100,† 101); Vap. (349†)
$C_{10}H_{14}N_2$	Nicotine (595)
$C_{10}H_{15}N$	Butylaniline (51, 153.2)
$C_{10}H_{15}N$	Diethylaniline (51)
$C_{10}H_{16}$	Limonene (100,† 101)
$C_{10}H_{16}$	Pinene (100,† 101)
$C_{10}H_{18}O$	Eucalyptol (100,† 101)
$C_{10}H_{18}O$	Terpineol (100,† 101)
$C_{10}H_{18}O_3$	Ethyl diethylacetoacetate (1†)
$C_{10}H_{20}$	Decylene (73,‡ 101)
$C_{10}H_{20}O$	Menthol (100,† 101)
$C_{10}H_{20}O$	Decyl aldehyde (378†)
$C_{10}H_{20}O_2$	Methylhexylcarbinyl acetate (652)
$C_{10}H_{20}O_2$	Amyl valerate (376†)
$C_{10}H_{20}O_2$	Isoamyl isovalerate (652)
$C_{10}H_{22}$	Decane (101)
$C_{10}H_{22}O$	Decyl alcohol (377†)
$C_{10}H_{22}O$	Amyl ether (1†)
$C_{10}H_{22}O_2$	α-Dimethyl-β-hexylglycol (377†)
$C_{10}H_{23}N$	Diisoamylamine (52.3, 153.3)
$C_{11}H_{11}N$	Methyl-α-naphthylamine (153.3)
$C_{11}H_{12}O$	Allylacetophenone (374,† 375†)
$C_{11}H_{12}O_2$	Ethyl cinnamate (374,† 375†)
$C_{11}H_{12}O_3$	Ethyl benzoylacetate (376†)
$C_{11}H_{14}O$	Isobutyl phenyl ketone (378†)
$C_{11}H_{16}N_2O_2$	Pilocarpine (595)
$C_{11}H_{17}N$	Isoamylaniline (51, 153.2)
$C_{11}H_{22}O$	Undecyl aldehyde (378†)
$C_{11}H_{24}O$	Undecyl alcohol (377†)
$C_{11}H_{24}O_2$	α-Methyl-α-ethyl-β-hexylglycol (377†)
$C_{12}H_{10}$	Diphenyl: CCl_4, C_6H_6 (101)
$C_{12}H_{10}N_2$	Azobenzene (101)
$C_{12}H_{10}O_3$	Ethyl salicylate (592.2)
$C_{12}H_{11}N$	Diphenylamine: P (52.1, 153.3)
$C_{12}H_{13}N$	Dimethyl-α-naphthylamine (153.3)
$C_{12}H_{13}N$	Ethyl-α-naphthylamine (153.3)
$C_{12}H_{14}O_3$	Eugenyl acetate (101)
$C_{12}H_{14}O_4$	Diethyl phthalate (592.2)
$C_{12}H_{19}N$	Dipropylaniline (51, 153.2)
$C_{12}H_{22}O_6$	Dibutyl tartrate (375†)
$C_{12}H_{22}O_{11}$	Saccharose (102)
$C_{12}H_{22}O_{11}$	Lactose (102)
$C_{12}H_{22}O_{11}$	Maltose (102)
$C_{12}H_{24}$	Dodecylene (73,‡ 101)
$C_{12}H_{26}$	Dodecane (101)
$C_{12}H_{26}O$	Dodecyl alcohol (377†)
$C_{12}H_{26}O_2$	α-Methyl-α-propyl-β-hexylglycol (377†)

Formula	Name, solvents and literature
	Infra-red.—(*Continued*)
$C_{12}H_{27}N$	Tri-*n*-butylamine (52.3)
$C_{13}H_{27}Cl$	Chlorotridecane (101)
$C_{14}H_{15}N$	Dibenzylamine (52.2, 153.3)
$C_{14}H_{17}N$	Diethyl-α-naphthylamine (153.3)
$C_{14}H_{23}N$	Dibutylaniline (51, 153.2)
$C_{14}H_{26}O_6$	Diamyl tartrate (375†)
$C_{14}H_{29}Cl$	Chlorotetradecane (101†)
$C_{15}H_{21}NO_2$	β-Eucaine (595)
$C_{15}H_{21}N_3O_2$	Eserine (595)
$C_{15}H_{28}O_4$	Diethyl dibutylmalonate (375†)
$C_{15}H_{30}$	Pentadecylene (73,† 101)
$C_{15}H_{33}N$	Triisoamylamine (52.3, 153.3)
$C_{16}H_{16}O$	1-Phenyl-2-benzoylpropane (378)
$C_{16}H_{21}NO_3$	Homoatropine (595)
$C_{16}H_{32}$	Hexadecylene (73,† 101)
$C_{16}H_{34}$	Hexadecane (101)
$C_{17}H_{19}NO_3$	Piperine (595)
$C_{17}H_{22}ClNO_4$	Cocaine hydrochloride (595)
$C_{17}H_{23}NO_3$	Atropine (595)
$C_{17}H_{35}Cl$	Chloroheptadecane (101)
$C_{18}H_{15}N$	Triphenylamine: P (52.1, 153.3)
$C_{18}H_{20}O_2$	Ethyl dibenzylacetate (1†)
$C_{18}H_{21}NO_3$	Codeine (595)
$C_{18}H_{32}O_{16}$	Raffinose (102)
$C_{18}H_{34}O_2$	Oleic acid (101, 104, 105)
$C_{18}H_{36}$	Octadecylene (101)
$C_{18}H_{36}O_2$	Stearic acid (101)
$C_{18}H_{38}$	Octadecane (101)
$C_{19}H_{22}N_2O$	Cinchonidine (595)
$C_{19}H_{36}$	Hydrocarbons (101)
$C_{20}H_{24}N_2O_2$	Quinidine (595)
$C_{20}H_{24}N_2O_2$	Quinine (595)
$C_{21}H_{21}N$	Tribenzylamine (52.2, 153.3)
$C_{22}H_{23}NO_7$	Narcotine (595)
$C_{22}H_{42}$	Hydrocarbons (101)
$C_{23}H_{26}N_2O_4$	Brucine (102, 595)
$C_{23}H_{46}$	Tricosylene (101)
$C_{23}H_{48}$	Tricosane (101)
$C_{24}H_{48}$	Tetracosylene (101)
$C_{24}H_{50}$	Tetracosane (100, 101)
$C_{26}H_{52}O_2$	Cerotic acid (101†)
$C_{30}H_{62}O$	Myricyl alcohol (100, 101)
$C_{34}H_{47}NO_{11}$	Aconitine (595)
$C_{40}H_{50}N_4O_8S$	Quinine sulfate (595)

Organic Compounds of Mixed or Unknown Composition

Alcohols ($C_nH_{2n+1}OH$) (374†).
α-Alcohols (R.CH:CHOH) (374†).
β-Alcohols (R.CH:$CHCH_2OH$) (374†).
Asphaltum (mixed hydrocarbons) (101, 103, 417).
Bakelite (105).
Belladonna ($C_{17}H_{21}NO_4$ and $C_{17}H_{23}NO_3$) (595).
Boxwood oil (399).
Bromocarbinols ($CH_2BrCHBr.CHOHR$) (374†).
Castor oil (653).
Catfish oil (105).
Celluloid (399, 653†).
Cottonseed oil (105, 152, 153, 186).
Fatty acid esters (374†).
Gelatin (104).
Illuminating gas: Vap. (101).
Juniper oil (148).
Kerosene (153); *cf.* Vol. II, p. 153.
Ketones (374†).
Lard oil (105, 153).
Lavender oil (148†).
Linseed oil (104).
Linseed oil fatty acids (105).
Nitrocellulose (celluloids, pyralin) (103, 105).
Ohio oils (101).
Olive oil (1,† 104, 105, 148,† 555†).
Paraffin oil (105, 169,† 555,† 558†); *cf.* Vol. II, p. 153.
Peanut oil (105).
Petroleum (101, 153, 555†); *cf.* Vol. II, p. 153.
Poplar oils (399).
Resin (101).
Rubber (102, 555,† 558,† 653†).
Rosemary oil (148†).
Salicylic acid esters (HOC_6H_4COOR) (374).
Sassafras oil (148†).
Silk, oiled (555†).
Soya bean oil (105).
Tung oil (105).
Turpentine (1,† 101, 148†).
Vinyl carbinols (CH_2:CH.CHOHR) (374†).

Formula	Name, solvents and literature
	Ultra-violet and Visible
$CBrN_3O_6$	Bromonitroform: EtOH (198)
$CBr_2N_2O_4$	Dibromodinitromethane: EtOH (198)
CBr_4	Carbon tetrabromide (440†)
$CClN_3O_6$	Chloronitroform: EtOH (198)
CCl_2O	Carbonyl chloride: Liq., Vap. (83†)
CCl_2S	Thiocarbonyl chloride: EtOH (536†)
CCl_4	Carbon tetrachloride (261,† 440†)
CI_4	Carbon tetraiodide: EtOH (442†)
CN_4O_8	Tetranitromethane: EtOH (259, 421, 664); EtOH and other solvents (259, 421); $CHCl_3$ (421)
CS_2	Carbon disulfide: Liq., Vap. (486)
$CHBrN_2O_4$	Bromodinitromethane: H_2O (259, 291); HCl (259, 291); Et_2O (291); K salts: H_2O (198, 291)
$CHBr_3$	Bromoform (440†)
$CHCl_3$	Chloroform (261,† 440†)
CHI_3	Iodoform: EtOH (116, 386, 442,† 493,† 573‡); CCl_4 (493,† 573‡); C_6H_6 (493†); hexane (573‡)
CHN	Hydrocyanic acid (262†)
CHNO	Cyanic acid, K salt: H_2O (280†)
CHNS	Thiocyanic acid, Co salt (227); Et_2O (320); Hg salt: EtOH (113)
CHN_3O_6	Nitroform (228); H_2O (291); H_2SO_4 (198, 255); EtOH (259); Et_2O (291); Ag salt: H_2O, Et_2O (255); Hg salt: H_2O, $CHCl_3$, EtOH (255); K salt: H_2O (198, 255, 291); Na salt: EtOH (244†)
CH_2Br_2	Methylene bromide (440†)
CH_2Cl_2	Methylene chloride (440†)
CH_2I_2	Methylene iodide: EtOH (116, 442†)
$CH_2N_2O_4$	Dinitromethane (228); Et_2O (291); H_2O (255, 291); H_2SO_4, NaOH (255); Na salts: EtOH (244); K salt: H_2O (291)
$CH_2N_2O_6S_2$	Diazomethanedisulfonic acid, K salt: KOH (247)

Formula	Name, solvents and literature
	Ultra-violet and Visible.—(*Continued*)
CH_2O	Formaldehyde (54, 83); Vap. (83, 538); EtOH (534†); *cf.* p. 359
CH_2O_2	Formic acid (54,‡ 56,‡ 57,‡ 60,‡ 182,‡ 240, 298‡); P (252); H_2O (240, 252, 659,† 660); EtOH (240, 252); Ba, Ca, K, Li, Mg, Sr salts: H_2O = ? (660); Co salt: H_2O (320); Na salt: H_2O (182, 659,† 660); NH_4 salt: H_2O (240, 660)
CH_2S_3	Trithiocarbonic acid: $CHCl_3$, $C_6H_5CH_3$, ligroin (212‡); Ba salt: H_2O (212‡)
CH_2S_4	Perthiocarbonic acid: $CHCl_3$, $C_6H_5CH_3$, ligroin (212‡); Na salt: H_2O (212‡)
CH_3I	Methyl iodide (442†); EtOH (116)
CH_3NO_2	Nitromethane (655†); H_2O (291, 664); EtOH (25, 255, 664); H_2SO_4 (255); alk. (25, 255, 664); Vap. (540); Na salt: H_2O (291); EtOH (244)
$CH_3N_3O_3$	Nitrourea: EtOH + alk. (25)
CH_4	Methane (192†)
CH_4N_2	Hydrazomethane (247)
CH_4N_2O	Urea (25, 594); *cf.* p. 359
$CH_4N_2O_2$	Methylnitroamine and salts; EtOH (25); Co salt: H_2O (162); Cu salt: H_2O (163); Ni salt: H_2O (163, 164)
CH_4N_2S	Thiourea (424); *cf.* p. 359
CH_4N_2S	Ammonium thiocyanate (424)
$CH_4N_4O_2$	Nitroguanidine: EtOH + alk. (25)
CH_4O	Methyl alcohol (54, 56, 286,† 438†)
CH_4O_3S	Methylsulfonic acid, Na salt (567)
CH_5N	Methylamine (63)
CH_6ClN	Methylamine hydrochloride: H_2O (276†)
CH_6ClN_3	Guanidine hydrochloride: *cf.* p. 359
C_2Cl_4	Tetrachloroethylene: EtOH (441†)
C_2Cl_6	Hexachloroethane: EtOH (441†)
C_2I_2	Diiodoacetylene (423‡)
C_2HCl_3O	Chloral: Et_2O, Vap. (538); *cf.* p. 359
$C_2HCl_3O_2$	Trichloroacetic acid (182‡); H_2O (182,‡ 231, 240, 659†); EtOH, Et_2O (240); ligroin (231, 240); HCl, H_2SO_4 (231); NH_4 salt: H_2O, EtOH (240); Na salt: H_2O (182,‡ 659)
C_2H_2	Acetylene (261,† 303, 600, 601); EtOH, Me_2CO (441†)
$C_2H_2Br_2$	Dibromoethylene, *cis* and *trans: v.* p. 359
$C_2H_2Cl_2$	Dichloroethylene, *cis* and *trans:* EtOH, hexane (154†); *cf.* p. 359
$C_2H_2Cl_4$	*sym.*-Tetrachloroethane: EtOH (441†)
$C_2H_2I_2$	Diiodoethylene (423‡); *cf.* p. 359
$C_2H_2N_2O_4$	Azodicarboxylic acid; K salt: KOH (247)
C_2H_2O	Ketene: hexane (370,‡ 371‡); *cf.* p. 359
$C_2H_2O_2$	Glyoxal: EtOH (538); hexane (418,‡ 419‡); Vap. (418, 538); *cf.* p. 359
$C_2H_2O_4$	Oxalic acid (54, 56,‡ 58,‡ 66,‡ 428,† 645.5†); H_2O (252, 659,† 660†); EtOH (252); *cf.* p. 359; Co salt: H_2O (320); K salt: H_2O (252, 659†); Na salt: H_2O (660†)
C_2H_3ClO	Acetyl chloride: hexane (252)
$C_2H_3ClO_2$	Chloroacetic acid: (182‡); HCl (240); H_2O (231, 659†); EtOH (231, 240); K, NH_4 salts: H_2O (240); Metallic salts: H_2O (231); Na salt: H_2O (182,‡ 659†)
$C_2H_3Cl_3O_2$	Chloral hydrate: EtOH (538); *cf.* p. 359
C_2H_3N	Methyl isocyanide (63‡)
C_2H_3N	Acetonitrile (63‡)
C_2H_3NO	Methyl isocyanate: P (280†)
$C_2H_3NO_3$	Isonitrosoacetic acid: EtOH, EtOH + alk. (31)
$C_2H_3NO_4$	Nitroacetic acid: EtOH, Et_2O (255); K salt: H_2O (255)
C_2H_4	Ethylene: Vap. (261,† 601, 602)
$C_2H_4Cl_2$	Ethylene chloride (261†)
$C_2H_4I_2$	Ethylene iodide: EtOH (116, 423)
$C_2H_4NO_3$	Nitroacetaldoxime (255†)
$C_2H_4N_2O_3$	Ethylnitrolic acid: MeOH (245); K salt: MeOH (245); *iso*-K salt: MeOH (245)
$C_2H_4N_2O_3$	Methazonic acid: Et_2O, H_2O, NaOH (255)
$C_2H_4N_2O_4$	Dinitroethane and K salt: H_2O (291)
$C_2H_4N_4$	Tetrazine: Vap. (386)
$C_2H_4N_4O_2$	Azodicarbonamide (247)
C_2H_4O	Acetaldehyde (54,‡ 56,‡ 59,‡ 65,‡ 176.2† 309,‡ 310,‡ 538,‡ 571); hexane (419‡); EtOH, Vap. (538); *v.* p. 359
C_2H_4OS	Thioacetic acid and K salt (252)
$C_2H_4O_2$	Acetic acid (54,‡ 55,‡ 56,‡ 57,‡ 58,‡ 59,‡ 60,‡ 64,‡ 66,‡ 67,‡ 298,‡ 382†); H_2O (65, 182,‡ 204,‡ 231, 240, 252); P (240, 252); EtOH (231, 240, 252); Et_2O, hexane (240); MeOH, C_5H_{11}-OH (252); ligroin (231, 252); *cf.* p. 359; Ba salt: H_2O (231, 660†); Ca salt: H_2O (660†); Co salt (331,‡ 388); Cu salt (331,‡ 382); Hg salt (96); H_2O (113); K salt: H_2O (231, 240, 252, 660†); Li, Mg salt: H_2O (660†); NH_4 salt: H_2O (231, 240, 660†); Ni salt: H_2O (331‡); Na salt: (182‡); H_2O (240, 659,† 660†); Pb salt: H_2O (272); Sr, Zn salt: H_2O (660†)
$C_2H_4O_2$	Methyl formate (55,‡ 57,‡ 60,‡ 240, 252)
$C_2H_4O_2$	Glycollic aldehyde: H_2O, EtOH (425†)
C_2H_5Cl	Ethyl chloride (261†)
C_2H_5ClO	Ethylene chlorohydrin (592.3); P, C_6H_6, Vap. (372.2†)
C_2H_5ClO	Ethyl hypochlorite: ligroin (562, 568)
C_2H_5I	Ethyl iodide: EtOH (116, 386, 573‡); C_6H_6 (386); H_2O, hexane, CCl_4 (573‡)
C_2H_5NO	Acetaldoxime (63†); H_2O (276†)
C_2H_5NO	Acetamide (63†); *cf.* p. 359
$C_2H_5NO_2$	Aminoacetic acid: *v.* p. 359; Co salt (397†); H_2O (396); Cu salt (382†); H_2O (391)
$C_2H_5NO_2$	Nitroethane (228); EtOH (25, 255, 664); alk. (255, 664)
	Ethyl nitrite: EtOH, EtOH + EtSH (259)
$C_2H_5NO_2$	Ethyl nitrate: EtOH (240, 562); ligroin (566)
$C_2H_5NO_3$	
$C_2H_5N_3$	Triazoethane: *v.* p. 359
$C_2H_5N_3O_2$	Biuret (594)
$C_2H_6N_2$	Azomethane (247): Vap. (540.5)
$C_2H_6N_2O$	Dimethylnitrosoamine: EtOH (25)
$C_2H_6N_2O_2$	Ethylnitroamine, Co derivative (162); Cu salt (163); Ni salt (164)
$C_2H_6N_2O_2$	Ethylnitrosohydroxylamine, Cu salt: H_2O (163)
C_2H_6O	Ethyl alcohol (54,‡ 56,‡ 298,‡ 438†)
$C_2H_6O_3S$	Ethylsulfonic acid, K salt (567)
C_2H_6S	Dimethyl sulfide: EtOH (242)
C_2H_7N	Ethylamine (63‡)
C_2H_7N	Dimethylamine (63‡)
C_2H_7NO	Colamine: *v.* p. 359
$C_2H_8N_2$	Ethylenediamine (63‡); (+ HCl) *cf.* p. 359

Formula	Name, solvents and literature
	Ultra-violet and Visible.—*(Continued)*
$C_3Cl_3N_3$	Cyanuric chloride: EtOH (280†)
C_3HBr_5O	Pentabromoacetone (176)
$C_3H_2N_2O_3$	Parabanic acid: *v.* p. 359
$C_3H_3NO_6$	Nitromalonic acid, salts: H_2O (255)
C_3H_3NS	Thiazole (554)
$C_3H_3N_3O_3$	Cyanuric acid: H_2O (262, 280); *cf.* p. 359
$C_3H_3N_3O_3$	Nitrocyanacetamide: H_2SO_4, Et_2O (258); Na salt: H_2O (258)
$C_3H_4Br_2N_2O_2$	Dibromomalonamide: H_2O (198)
$C_3H_4Cl_2O$	Dichloroacetone (176)
$C_3H_4N_2$	Pyrazole (554)
$C_3H_4N_2$	Glyoxaline (554)
$C_3H_4N_2O_4$	Oxaluric acid (594); *cf.* p. 359
C_3H_4O	Acrolein (59,‡ 539); H_2O, hexane, Et_2O (418‡); Vap. (418, 539); *cf.* p. 359
$C_3H_4O_2$	Acrylic acid: hexane (418‡); *cf.* p. 359
$C_3H_4O_2$	Methylglyoxal: *v.* p. 359
$C_3H_4O_3$	Pyruvic acid (62,‡ 66,‡ 68‡); *cf.* p. 359
$C_3H_4O_4$	Malonic acid (54,‡ 56,‡ 58‡); H_2O (659,† 660†); Na salt: NaOH (82); H_2O (659,† 660†)
C_3H_5Br	Allyl bromide: EtOH, Vap. (539)
$C_3H_5BrN_2O_2$	Bromomalonamide: H_2O (198)
C_3H_5ClO	Chloroacetone (176); EtOH, Vap. (538)
C_3H_5NO	Ethyl isocyanate: P (280†); hexane (370,‡ 371‡)
$C_3H_5NO_2$	Isonitrosoacetone (176); EtOH, alk. (31)
$C_3H_5N_3O_9$	Nitroglycerol: H_2O (311)
$C_3H_6N_2$	Pyrazoline (554)
$C_3H_6N_2O_2$	Malonamide: H_2O, NaOH (82, 198)
$C_3H_6N_2O_3$	Urethanediazohydroxide, Na salt: H_2O (247)
$C_3H_6N_2O_3$	Nitrosourethane: EtOH (25)
$C_3H_6N_2O_4$	Nitrourethane: EtOH, alk. (25)
$C_3H_5N_2O_7$	Glyceryl α-β(γ)-dinitrate: H_2O (311)
$C_3H_6N_6$	Melamine: H_2O (280)
C_3H_6O	Allyl alcohol: hexane (58,‡ 418); P (261†); EtOH (428, 539); Vap. (418, 539); *cf.* p. 359
$C_3H_6OS_2$	Xanthic acid: ligroin (211, †252); EtOH (211,† 252); Et_2O (211†); K salt: H_2O (252)
C_3H_6O	Acetone (54,‡ 56,‡ 59,‡ 61,‡ 62,‡ 65,‡ 66,‡ 67,‡ 69,‡ 98, 175, 176, 191,† 228, 294, 308,‡ 309,‡ 310,‡ 410, 534, 545,‡ 574, 598,‡ 601); H_2O (82, 204,‡ 497,‡ 609); EtOH (82, 220, 404, 497,‡ 538, 546,† 609); NaOH, HCl (82); various sol. (546,† 573‡); Vap. (538†); *cf.* p. 359
C_3H_6O	Propionaldehyde (54,‡ 56,‡ 59‡); EtOH, Vap. (538); *cf.* p. 359
$C_3H_6O_2$	Ethyl formate (55,‡ 57,‡ 60‡); P, ligroin, Et_2O, EtOH (252)
$C_3H_6O_2$	Methyl acetate (54,‡ 56,‡ 57,‡ 60‡); H_2O, EtOH, Et_2O, hexane (240)
$C_3H_6O_2$	Propionic acid (54,‡ 55,‡ 56,‡ 57,‡ 58,‡ 60,‡ 252); H_2O (659,† 660†); *cf.* p. 359; Ba, Ca, K, Li, Mg, Na, NH_4, Sr salts: H_2O (659,† 660†)
$C_3H_6O_2S$	Monoethylthiocarbonic acid (252)
$C_3H_6O_3$	Lactic acid (58‡); $CHCl_3$ (134); *cf.* p. 359
$C_3H_6S_3$	Ethyl trithiocarbonate: ligroin, Et_2O (212‡); K salt: H_2O (212‡)
$C_3H_6S_3$	Trithioformaldehyde (534†)
C_3H_7NO	Propionamide (63‡); EtOH (390); *cf.* p. 359; Hg salt (390)
C_3H_7NO	Acetoxime (63,‡ 276†); *cf.* p. 359
$C_3H_7NO_2$	Urethane: EtOH + NaOEt (82)
$C_3H_7NO_2$	α-Alanine (594); EtOH (650‡); *cf.* p. 359; Co salt (397†); Cu salt (382†); H_2O (391); β-Alanine, Cu salt: EtOH (391)
$C_3H_7NO_2$	1(2)-Nitropropane: EtOH, EtOH + MeONa (664)
$C_3H_7NO_2$	Dimethyl thiosulfocarbamate, Co salt: $CHCl_3$ (123)
$C_3H_7NO_5$	Glyceryl α(β)-mononitrate: H_2O (311)
$C_3H_7NO_3$	Serine (265,† 594†)
$C_3H_8N_2O_2$	α(β)-Diaminopropionic acid (391‡)
$C_3H_8N_2O_2$	Propylnitroamine: H_2O (162)
C_3H_8O	Propyl alcohol (54,‡ 56,‡ 58,‡ 438†)
C_3H_8O	Isopropyl alcohol (261†)
$C_3H_8O_2$	Methylal (534†)
C_3H_9N	Propylamine (63‡)
C_3H_9N	Trimethylamine (63‡); EtOH (286)
$C_4HBr_2NO_2$	Dibromomaleinimide: EtOH (389)
$C_4H_2BrNO_2$	Bromomaleinimide: EtOH (389)
$C_4H_2O_3$	Maleic acid anhydride (171‡); AcOH, H_2SO_4 (500); *cf.* p. 359
$C_4H_2O_4$	Acetylenedicarboxylic acid (423)
$C_4H_3ClN_2O_2$	Aminochloromaleinimide: EtOH (389)
$C_4H_3N_3O_4$	Violuric acid: H_2O, EtOH (269†); Na salt: H_2O (269†); *cf.* p. 359
$C_4H_3N_3O_5$	Nitrobarbituric acid (228); H_2O, H_2SO_4, NaOH (255)
$C_4H_4BrNO_2$	Succinbromoimide: EtOH (199)
$C_4H_4ClNO_2$	Succinchloroimide: EtOH (199)
$C_4H_4N_2O_3$	Barbituric acid (129†); H_2O (269†); *cf.* p. 359
$C_4H_4N_2O_5$	Alloxan (129†); H_2O (269†); K salt: EtOH (269†)
C_4H_4O	Furan: EtOH (273,† 511†); Vap. (511); *cf.* p. 359
$C_4H_4O_2$	Methyl propiolate (58‡)
$C_4H_4O_2$	Diketocyclobutane: hexane, Et_2O (370,‡ 371‡)
$C_4H_4O_4$	Fumaric acid (64,‡ 423); H_2O (659†); EtOH (237, 429,† 430,† 607); Na salt: H_2O (659†)
$C_4H_4O_4$	Maleic acid (58,† 64,† 423, 607); EtOH (429,† 430†); Et_2O (237); *cf.* p. 359
$C_4H_4O_5$	Oxalacetic acid and salts: H_2O, HCl, EtOH, Et_2O (237)
$C_4H_4O_5$	Hydroxyfumaric acid: Et_2O (237)
$C_4H_4O_6$	Dihydroxyfumaric acid: EtOH (237)
C_4H_4S	Thiophene: P (486,† 511†); EtOH (273,† 511†); Vap. (486,† 511†); *cf.* p. 359
$C_4H_5ClN_2$	3-Methyl-5-chloropyrazole (554)
$C_4H_5ClO_2$	β-Chlorocrotonic acid (84,‡ 424); H_2O (252); β-Chloroisocrotonic acid (84,‡ 424)
$C_4H_5Cl_3O_2$	Ethyl trichloroacetate: EtOH, Et_2O (240); ligroin (231, 240)
C_4H_5N	Vinylacetonitrile (84‡)
C_4H_5N	Trimethylene carboxylicnitrile (84‡)
C_4H_5N	Pyrrole: P, Vap. (511); EtOH (273,† 361, 362, 511); hexane (171‡); *cf.* p. 359
C_4H_5N	Crotononitrile (84‡)
C_4H_5N	Isocrotononitrile (84‡)
C_4H_5N	Methylacrylonitrile (84‡)
$C_4H_5NO_2$	Succinimide (199); H_2O (389); EtOH (390); Mg salt: H_2O (389); Hg salt (390)
$C_4H_6N_2O$	Dimethylglyoxime anhydride (1.5)
$C_4H_6N_2O$	3-Methyl-5-pyrazolone (554)
$C_4H_6N_2O_2$	Ethyl diazoacetate: EtOH (247)
$C_4H_6N_4O_3$	Allantoin (594†); *cf.* p. 359

Formula	Name, solvents and literature
	Ultra-violet and Visible.—(*Continued*)
C_4H_6O	Crotonaldehyde: EtOH (539); Vap. (392, 539); hexane (392‡); *cf.* p. 359
$C_4H_6O_2$	Vinylacetic acid (84‡)
$C_4H_6O_2$	Trimethylenecarbonic acid (84‡)
$C_4H_6O_2$	Diacetyl (36, 59,‡ 62,‡ 66,‡ 69,‡ 175, 176, 294, 410); hexane (369,‡ 370‡); Vap. (370,‡ 538); *cf.* p. 359
$C_4H_6O_2$	Crotonic acid (58,‡ 59,‡ 64,‡ 66,‡ 84‡); H_2O (252, 497‡); EtOH (539, 607); Vap. (539); *cf.* p. 359
$C_4H_6O_2$	Isocrotonic acid (84‡)
$C_4H_6O_3$	Acetic anhydride: Et_2O (252)
$C_4H_6O_4$	Dimethyl oxalate: P, MeOH, EtOH, ligroin (120, 252)
$C_4H_6O_4$	Succinic acid (54,‡ 56,‡ 58,‡ 64,‡ 66‡); H_2O (659,† 660†); EtOH (120, 423, 607); *cf.* p. 359; Na salt: H_2O (659,† 660†)
$C_4H_6O_5$	Malic acid (58‡)
$C_4H_6O_6$	*d*(*l*)-Tartaric acid (58‡); H_2O (429,† 608, 660†); Co salt: H_2O (320); Na salt: H_2O (660†)
$C_4H_6O_6$	*dl*-Tartaric acid (58‡); H_2O (608)
$C_4H_6O_6$	Mesotartaric acid (608)
$C_4H_7ClO_2$	Ethyl chloroacetate: P (240); EtOH (231, 240)
C_4H_7NO	β-Hydroxybutyronitrile (84‡)
$C_4H_7NO_2$	Diacetylmonoxime (1.5)
$C_4H_7NO_2$	Isonitrosomethylacetone: EtOH, alk. (31)
$C_4H_7NO_3$	Acetylglycine: *v.* p. 359
$C_4H_7NO_4$	Aspartic acid: *v.* p. 359
$C_4H_7N_3O$	Creatinine: H_2O (266)
C_4H_8	Isobutylene: Vap. (601, 602)
$C_4H_8N_2O_2$	Dimethylglyoxime (36); Cu salt (1.5)
$C_4H_8N_2O_3$	*d* (*l*)-Asparagine: H_2O (429†); *cf.* p. 359
$C_4H_8N_2O_3$	Nitrosomethylurethane: Et_2O (247)
$C_4H_8N_2O_3$	Urethanediazohydroxide methyl ether: Et_2O (247)
$C_4H_8N_2O_7$	Glyceryl methyl ether dinitrate: H_2O (311)
C_4H_8O	Methyl ethyl ketone (54,‡ 56,‡ 59,‡ 62,‡ 176, 294, 545‡); P, H_2O, heptane, $CHCl_3$ (546†); EtOH (538,† 546,† 609); Vap. (538†)
C_4H_8O	Butyraldehyde (54,‡ 56,‡ 59‡)
C_4H_8O	Isobutyraldehyde: *v.* p. 359
$C_4H_8O_2$	Methyl propionate (55,‡ 57,‡ 58,‡ 60‡)
$C_4H_8O_2$	Ethyl acetate (54,‡ 55,‡ 56,‡ 57,‡ 204,‡ 309,‡ 310‡); P, EtOH (240, 252); H_2O (240)
$C_4H_8O_2$	*n*-Butyric acid (54,‡ 56,‡ 57,‡ 60‡); P, ligroin (252); H_2O (252, 659,† 660†); EtOH (252, 607); K salt: H_2O (252); Na salt (660†); H_2O (659†)
$C_4H_8O_2$	Propyl formate (55, 57, 60)
C_4H_8OS	1, 4-Thioxan: EtOH (189)
$C_4H_8O_2S_2$	Diethylene disulfoxide: H_2O (189)
$C_4H_8S_2$	Diethylene disulfide: EtOH (189)
C_4H_9I	Isobutyl iodide: EtOH (116)
C_4H_9NO	*tert.*-Nitrosobutane: Et_2O (25)
$C_4H_9N_3O_2$	Creatine: *v.* p. 359
$C_4H_{10}N_2$	Piperazine: EtOH; Vap. (520†)
$C_4H_{10}N_2O$	Diethylnitrosoamine: EtOH (25)
$C_4H_{10}O$	Ethyl ether (592.3)
$C_4H_{10}O$	*n*-Butyl alcohol (54,‡ 56,‡ 438)
$C_4H_{10}O$	*tert.*-Butyl alcohol (438)
$C_4H_{10}O$	Isobutyl alcohol (237†)
$C_4H_{10}O_3$	Methyl orthoformate: P, H_2O, EtOH (240)
$C_4H_{10}O_3S$	Diethyl sulfite (*sym.* and *unsym.*) (567, 661); P (562)
$C_4H_{10}O_4S$	Diethyl sulfate: P (562)
$C_4H_{11}N$	Diethylamine (63‡)
$C_4H_{14}Cl_2N_2$	Tetramethylenediamine (putresceine) hydrochloride: *v.* p. 359
C_5Cl_5N	Pentachloropyridine (14); Vap. (520)
C_5HCl_4N	2, 3, 4, 5-Tetrachloropyridine (14); Vap. (520)
$C_5H_2Cl_3N$	2, 3, 5-Trichloropyridine: Vap. (520)
$C_5H_2Cl_3N$	3, 4, 5-Trichloropyridine (14, 505†); Vap. (520)
$C_5H_2Cl_4$	Tetrachlorocyclopentadiene (410)
$C_5H_2Cl_4N_2$	Tetrachloro-2-aminopyridine: Vap. (520)
$C_5H_3Cl_2N$	3, 5-Dichloropyridine (504); Vap. (520)
$C_5H_4N_4O$	6-Hydroxypurine (594†); H_2O (127†)
$C_5H_4N_4O_2$	2,6-Dihydroxypurine (594†); H_2O (127†)
$C_5H_4N_4O_3$	Uric acid (122,‡ 594†); H_2O (127,† 269†); *cf.* p. 359; Li salt: H_2O (269†)
$C_5H_4O_2$	γ-Pyrone: EtOH, EtOH + NaOEt (21)
$C_5H_4O_2$	Furfuraldehyde: P, Vap. (511); H_2O (180); EtOH (180, 273,† 511); *cf.* p. 359
$C_5H_4O_3$	Pyromeconic acid: EtOH, EtOH + NaOEt (21)
$C_5H_4O_3$	Pyromucic acid (Furan-α-carboxylic acid): EtOH (273†); *cf.* p. 359
C_5H_5N	Pyridine (14, 38,‡ 428); P (486, 508); H_2O (33,† 39†); EtOH (223, 263,† 312,† 486, 606‡); $CHCl_3$, HCl (223); hexane (156,‡ 171,‡ 606‡); Et_2O (606‡); Vap. (312, 486, 508, 606‡); *cf.* p. 359
C_5H_5NO	α(β, γ)-Pyridone: EtOH (+HCl) (+NaOEt) (14)
C_5H_6	Cyclopentadiene: EtOH, Et_2O (618); *cf.* p. 359
C_5H_6ClN	Pyridine hydrochloride: H_2O (276†)
C_5H_6ClN	Pyridonium chloride: H_2O, H_2SO_4 (241)
$C_5H_6ClN_5O$	Guanine hydrochloride: EtOH (269†)
$C_5H_6N_2$	α-Aminopyridine: EtOH (+HCl) (386)
$C_5H_6N_2O_2$	Aminomethylmaleinimide: EtOH (389)
$C_5H_6O_2$	Furfuralcohol (66‡); *cf.* p. 359
$C_5H_6O_3$	Triketopentane: $CHCl_3$ (410)
$C_5H_6O_4$	Citraconic acid (58,‡ 64‡); EtOH (607)
$C_5H_6O_4$	Itaconic acid (58‡); EtOH (607)
$C_5H_6O_4$	Mesaconic acid (58,‡ 64‡); EtOH (607)
$C_5H_6O_5$	Acetone-1, 1′-dicarboxylic acid (176)
$C_5H_7BrO_4$	Dimethyl bromomalonate: EtOH (198)
C_5H_7NO	Acetylacetonemonoximeanhydride: EtOH (1.5)
$C_5H_7NO_2$	Ethyl cyanoacetate: H_2O, EtOH (+NaOH) (82)
$C_5H_7NO_3$	Isonitrosoacetylacetone (400); EtOH (+alk.) (31)
$C_5H_7N_3O_2$	3, 5-Dimethyl-4-nitropyrazole (554)
$C_5H_7N_3O_3$	Ethyl fulminurate: H_2O (255)
C_5H_8	β-Methylbutadiene (Isoprene): Vap. (601, 602); *cf.* p. 359
$C_5H_8N_2$	3, 5-Dimethylpyrazole (554)
C_5H_8O	Methyl allyl ketone: Et_2O, Vap. (539)
C_5H_8O	Methyl propenyl ketone: Et_2O, Vap. (539)
$C_5H_8O_2$	Acetylacetone (24, 62,‡ 69,‡ 294, 204,‡ 370‡); EtOH (1.5, 22, 24, 269,† 475, 476, 478); Vap. (538); *cf.* p. 359; metallic derivatives (22); Al, Be, Th (24); Ba, Ca, Cd, Co, Cr, Cu, Fe, Hg, Li, Sc, Th, Yt, Zn (476); Cu (1.5)
$C_5H_8O_2$	Allylacetic acid (58,‡ 64,‡ 66‡)
$C_5H_8O_2$	Acetylpropionyl (176)
$C_5H_8O_3$	Ethyl pyruvate (66,‡ 67,‡ 68,‡ 294); EtOH (609)

Formula	Name, solvents and literature
	Ultra-violet and Visible.—(*Continued*)
$C_5H_8O_3$	Methyl acetoacetate (62‡)
$C_5H_8O_3$	Levulinic acid: *v.* p. 359
$C_5H_8O_4$	Dimethyl malonate: H_2O, EtOH (+NaOH) (198); (+NaOH) (+HCl) (82)
$C_5H_9BrN_2O_2$	Bromomalondimethylamide: EtOH (198)
$C_5H_9NO_2$	Methylnitrotetramethylene: EtOH (553)
$C_5H_9NO_4$	Glutamic acid: *v.* p. 359
C_5H_{10}	Trimethylethylene: hexane (418); Vap. (602); *cf.* p. 359
C_5H_{10}	Methyltetramethylene: EtOH (553)
C_5H_{10}	Cyclopentane: EtOH (553)
C_5H_{10}	Amylene: P, EtOH (261†)
$C_5H_{10}ClNO_2$	Glutamic acid hydrochloride: EtOH (649)
$C_5H_{10}N_2$	Diethylcyanamide: hexane (370,‡ 371‡)
$C_5H_{10}N_2O_2$	Nitrosopiperidine: EtOH, Vap. (520)
$C_5H_{10}N_2O_2$	Acetylacetonedioxime (1.5)
$C_5H_{10}O$	Diethyl ketone (54,‡ 56,‡ 62,‡ 176, 545‡) P, H_2O, heptane, $CHCl_3$ (546†); EtOH (538, 546†); Vap. (538)
$C_5H_{10}O$	Methyl isopropyl ketone (176, 294, 545‡); P, H_2O, heptane, $CHCl_3$ (546†); EtOH (546,† 609)
$C_5H_{10}O$	Methyl propyl ketone (545‡); P, H_2O, heptane, $CHCl_3$ (546†); EtOH (546,† 609)
$C_5H_{10}O$	Cyclopentanol: EtOH (553)
$C_5H_{10}OS_2$	Diethyl dithiocarbonate: EtOH (536)
$C_5H_{10}OS_2$	Ethyl xanthate: EtOH (252, 536); Et_2O, ligroin (252); K salt: H_2O (252)
$C_5H_{10}O_2$	Propyl acetate (54,‡ 55,‡ 56,‡ 57,‡ 60‡)
$C_5H_{10}O_2$	*n*-Valeric acid (57,‡ 60‡)
$C_5H_{10}O_2$	Isovaleric acid and Na salt: H_2O (659†)
$C_5H_{10}O_2$	Methyl butyrate (54,‡ 57,‡ 60‡)
$C_5H_{10}O_2$	Ethyl propionate (55,‡ 57,‡ 60‡)
$C_5H_{10}O_2S$	Diethyl thiocarbonate: EtOH (252, 536†); K salt: H_2O, EtOH (252)
$C_5H_{10}O_2S$	Diethyl thioncarbonate: EtOH (252, 536†)
$C_5H_{10}O_3$	Diethyl carbonate: EtOH (536†)
$C_5H_{10}S_3$	Diethyl trithiocarbonate: EtOH (212,‡ 536); $CHCl_3$, ligroin (212‡)
$C_5H_{11}I$	Isoamyl iodide: EtOH (116)
$C_5H_{11}N$	Piperidine (398‡); P (509†); EtOH (263,† 312,† 395,† 509,† 520); (+acid) (520); Vap. (312,† 508)
$C_5H_{11}NO_2$	Amyl nitrite: EtOH (25); (+EtSH) (259)
$C_5H_{12}BrN$	Neurine hydrobromide: *v.* p. 359
$C_5H_{12}ClN$	Piperidine hydrochloride: EtOH (395†)
$C_5H_{12}ClNO_2$	Betaine hydrochloride: *v.* p. 359
$C_5H_{12}N_2O_2$	Piperidine hydronitrite: EtOH (259)
$C_5H_{12}O$	*n*(*tert.*)-Amyl alcohol (438)
$C_5H_{14}ClNO$	Choline hydrochloride: *v.* p. 359
$C_5H_{16}Cl_2N_2$	Cadaverine hydrochloride: *v.* p. 359
$C_6Br_4O_2$	Tetrabromobenzoquinone (410)
$C_6Cl_4O_2$	Tetrachlorobenzoquinone: $CHCl_3$ (403, 409, 411); $C_6(CH_3)_6$ (411)
C_6Cl_6	Hexachlorobenzene (261†); EtOH, Vap. (524†)
$C_6HCl_3O_2$	Trichlorobenzoquinone: EtOH (409, 610)
C_6HCl_6N	2, 3, 4-Hexachloropicoline (506); Vap. (520)
$C_6H_2Br_2O_2$	Dibromobenzoquinone (410)
$C_6H_2Cl_2O_2$	Dichlorobenzoquinone: EtOH (409, 411, 610)
$C_6H_2Cl_3NO_2$	2, 3, 4-Trichloropicolinic acid (506)
$C_6H_3BrO_2$	Bromo-*p*-benzoquinone: EtOH (610)
$C_6H_3Br_3O$	2, 4, 6-Tribromophenol: EtOH, Vap. (519)
$C_6H_3ClO_2$	Chlorobenzoquinone: EtOH (409, 610)
$C_6H_3Cl_2NO_2S$	4-Chloro-2-nitrophenylsulfur chloride: $CHCl_3$ (174.2‡)
$C_6H_3Cl_3N_2O$	2, 3, 4-Trichloropicolinamide (506); Vap. (520)
$C_6H_3Cl_3O$	2, 4, 6-Trichlorophenol: EtOH, Vap. (519)
$C_6H_3Cl_3S$	2, 5-Dichlorobenzenesulfur chloride: $CHCl_3$ (174.2‡)
$C_6H_3N_3O_6$	1, 3, 5-Trinitrobenzene: EtOH (34, 218, 249); NaOEt, $PhNMe_2$, C_6H_6 + $(C_6H_4{:}CH)_2$ (34); Na salt: EtOH (249): NaOEt (244)
$C_6H_3N_3O_7$	Picric acid (148.5); H_2O (77, 659†); EtOH (34, 77); heptane, NaOEt, $PhNMe_2$, C_6H_6, $(C_6H_4{:}CH)_2$, piperidine (34); HCl (34, 86); NaOH (86†); K, Na salts (209); H_2O (659,† 660†)
C_6H_4BrCl	*o*(*m*, *p*)-Chlorobromobenzene: EtOH, Vap. (524)
$C_6H_4Br_2$	*o*(*m*)-Dibromobenzene: P,† EtOH,† Vap. (515); *p*-Dibromobenzene: EtOH (386, 524); Vap. (524)
C_6H_4ClNO	*p*-Benzoquinone chloroimide: EtOH (282)
$C_6H_4ClN_3O_2$	*p*-Nitrobenzenediazonium chloride: H_2O (247)
$C_6H_4Cl_2$	*o*(*m*, *p*)-Dichlorobenzene (17); P,† Vap. (515, 524); EtOH (28, 515†)
$C_6H_4Cl_2N_2$	*p*-Benzoquinone dichloroimide: EtOH (282)
$C_6H_4Cl_2S$	4-Chlorobenzenesulfur chloride (174.2‡)
$C_6H_4I_2$	*o*(*m*)-Diiodobenzene: P,† EtOH,† Vap. (517)
$C_6H_4N_2O$	*p*-Benzoquinonediazide: EtOH (89, 247)
$C_6H_4N_2O_3$	Oxalosuccinonitrile (175)
$C_6H_4N_2O_4$	Pyrazine-2, 3-dicarboxylic acid and Fe, Na salts: H_2O (394)
$C_6H_4N_2O_4$	*o*(*p*)-Dinitrobenzene: EtOH (540, 640); *m*-: P (540†); EtOH (540, 640); hexane (640)
$C_6H_4N_2O_5$	2, 3(5)-Dinitrophenol (645‡)
$C_6H_4N_2O_5$	2, 6-Dinitrophenol: H_2O, HCl, NaOH (86); Na salt (209‡)
$C_6H_4N_2O_5$	2, 4-Dinitrophenol: H_2O (77, 86, 660); EtOH (77); HCl, NaOH (86); Na salt: H_2O (660)
$C_6H_4N_4O_6$	Picramide: EtOH (472)
$C_6H_4O_2$	*p*-Benzoquinone (410, 432,‡ 594,† 637); H_2O (288, 610); EtOH (36, 234, 244, 288, 405, 406, 409, 411); Et_2O (288); EtOH + p-$C_6H_4(OH)_2$, PhOH + $CHCl_3$ (234); hexane (356‡); Vap. (288, 408, 531); *cf.* p. 359.
$C_6H_4O_4$	Dihydroxyquinone: EtOH (409)
C_6H_5Br	Bromobenzene: P (514†); EtOH (386, 486,† 514,† 610); Vap. (202, 486, 514, 658)
$C_6H_5BrN_2O_4S$	*p*-Bromobenzenediazonium sulfate: H_2O (247)
C_6H_5BrO	*p*-Bromophenol: EtOH (385, 519); EtOH + NaOEt (385); Vap. (519)
C_6H_5Cl	Chlorobenzene (37‡); P (514†); EtOH (17, 20, 386, 486,† 514,† 530); Vap. (202, 301,‡ 486, 514, 647, 658)
$C_6H_5ClN_2$	Benzenediazonium chloride: H_2O (247)
$C_6H_5ClN_2O_3S$	*o*-Chlorobenzene-*anti*(*syn*)-diazosulfonic acid, K salt: H_2O (247)
C_6H_5ClO	*o*-Chlorophenol: EtOH (386, 540); Vap. (540)
C_6H_5ClO	*m*-Chlorophenol: EtOH, Vap. (540)
C_6H_5ClO	*p*-Chlorophenol: EtOH (385, 540); EtOH + NaOEt (385); Vap. (540)
$C_6H_5Cl_2N$	2, 4-Dichloroaniline: EtOH, acid, Vap. (519)
C_6H_5F	Fluorobenzene: EtOH (386); Vap. (624)
C_6H_5I	Iodobenzene: P (517†); EtOH (386, 486,† 517†); Vap. (202,† 486, 517)
C_6H_5IO	*p*-Iodophenol: EtOH, Vap. (519)

Formula	Name, solvents and literature
	Ultra-violet and Visible.—(*Continued*)
C_6H_5NO	Nitrosobenzene: EtOH (25, 26)
$C_6H_5NO_2$	Nitrobenzene (37‡); P (34, 540†); H_2O (637); EtOH (20, 34, 118, 434, 486,† 540, 637); hexane (637); $PhNMe_2$, H_2SO_4 (34); Vap. (540)
$C_6H_5NO_2$	*p*-Nitrosophenol: EtOH (+NaOEt) (26, 282)
$C_6H_5NO_2$	Picolinic acid (388); H_2O (394); Co salts (388); Fe salt: H_2O (394)
$C_6H_5NO_2$	Nicotinic acid: *v.* p. 359
$C_6H_5NO_3$	*o*-Nitrophenol (432,‡ 637, 638, 660); H_2O (43, 286); EtOH (26, 43, 185, 386†); (+NaOEt) (26, 43, 185); ligroin (43); Vap. (540); Na salt (660)
$C_6H_5NO_3$	*m*-Nitrophenol (286,† 432,‡ 637, 638); H_2O, ligroin (43); EtOH (+NaOEt) (26, 43)
$C_6H_5NO_3$	*p*-Nitrophenol (228, 386,† 432,‡ 637, 638, 660); H_2O (43, 255, 286); EtOH (26, 43, 77, 185, 255); EtOH + alk. (26, 40,† 43, 185, 255); ligroin (43, 255); Na salt (660)
$C_6H_5NO_4$	Citrazinic acid: H_2O (14)
$C_6H_5NO_6S$	*m*-Nitrobenzenesulfonic acid: H_2SO_4 (34)
$C_6H_5N_3$	Triazobenzene: *v.* p. 359
$C_6H_6N_3O_3$	*p*-Nitrobenzenenitrosoamine: $CHCl_3$ (247)
$C_6H_6N_3O_3$	*p*-Nitrobenzenediazonium hydroxide: Et_2O, KOH (247)
$C_6H_5N_3O_4$	2, 4-Dinitroaniline: EtOH (477)
$C_6H_5N_3O_4$	3, 5-Dinitroaniline: EtOH (218)
$C_6H_5N_3O_5$	4, 6-Dinitro-3-aminophenol: EtOH (477)
$C_6H_5N_3O_5$	Picramic acid: EtOH, HCl, NaOH (453)
$C_6H_5N_3O_5$	Isopicramic acid: EtOH, HCl, NaOH (453)
C_6H_6	Benzene (132,† 191,† 299, 300, 386, 530, 592.3); P (486); EtOH (20, 271,† 274,† 286, 335,† 431,† 443,† 483.5, 486†); hexane (156,‡ 171, 604‡); Vap. (170, 202, 271, 300, 483.5, 486, 584, 599, 601, 606,‡ 658); *cf.* p. 359
C_6H_6	Dipropargyl: EtOH, Vap. (600, 601)
C_6H_6	Dimethyldiacetylene (423)
C_6H_6BrN	*o*(*m*, *p*†)-Bromoaniline: EtOH (+acid), Vap.† (519)
C_6H_6ClN	*o*(*m*, *p*)-Chloroaniline: EtOH (+acid) (28); Vap. (540)
$C_6H_6Cl_6$	Hexachlorocyclohexane: EtOH, Vap. (524†)
C_6H_6IN	*o*(*m*, *p*)-Iodoaniline: EtOH, (+acid), Vap. (519)
$C_6H_6N_2O$	Benzenediazonium hydroxide, K salt (147); Na salt (247)
$C_6H_6N_2O$	Benzene-*anti*-diazoniumhydroxide, Na salt (247)
$C_6H_6N_2OS$	Thionylphenylhydrazine: EtOH (334)
$C_6H_6N_2O_2$	*o*-Nitroaniline (386†); EtOH (90, 472, 540); (+HCl) (+NaOH) (90); Vap. (540)
$C_6H_6N_2O_2$	*m*-Nitroaniline: H_2O (286); EtOH (26, 43)
$C_6H_6N_2O_2$	*p*-Nitroaniline: H_2O (286); EtOH (26, 43, 90); HCl (26, 90); NaOH (90)
$C_6H_6N_2O_2$	*p*-Benzoquinonedioxime, EtOH (282)
$C_6H_6N_2O_2$	*α*-Amino-*β*-pyridinecarboxylic acid: EtOH (386)
$C_6H_6N_2O_3$	2(2, 3, 4, 5)-Nitro-4(5, 4, 3, 2)-aminophenol: EtOH (477)
$C_6H_6N_2O_3S$	Benzene-*anti*(*syn*)-diazosulfonic acids, K, Na salts: H_2O (147, 247)
$C_6H_6N_2O_4S$	*p*-Sulfobenzene-*anti*(*syn*)-diazonium hydroxide, K, Na salts (147)
C_6H_6O	Phenol (530, 636, 637, 642); P (351,‡ 540); H_2O (286, 350, 351,‡ 385, 636,† 638, 659,† 660†); EtOH (27, 281, 351,‡ 384, 385, 638); $CHCl_3$, ligroin (385); hexane (352,‡ 355,‡ 370‡); pentane, CCl_4 (351‡); $C_6H_5CH_2OH$ (350); NaOH (27, 385, 386, 638); HCl (386, 636†); Vap. (161,† 351, 540, 658); *cf.* p. 359
$C_6H_6O_2$	Catechol: P, Vap. (540); H_2O (427, 429†); EtOH (267); hexane (352‡); *cf.* p. 359
$C_6H_6O_2$	Quinol: H_2O (228, 427, 429†); EtOH (267); NaOH (27); hexane (352‡); Vap. (288, 540†); *cf.* p. 359
$C_6H_6O_2$	Resorcinol: H_2O (427, 429†); EtOH (267); hexane (352‡); *cf.* p. 359
$C_6H_6O_2S$	Benzenesulfinic acid and Na salt: EtOH (189)
$C_6H_6O_3$	Pyrogallol: H_2O (281, 286, 290); HCl, NaOH (290)
$C_6H_6O_3$	Phloroglucinol: H_2O (281, 290); Et_2O, NaOH, HCl (290)
$C_6H_6O_3$	Triacetic lactone: EtOH, NaOEt (21)
$C_6H_6O_3S$	Benzenesulfonic acid (182,‡ 660); Na salt (182‡)
$C_6H_6O_6$	Aconitic acid (58,‡ 64‡); EtOH (607); *cf.* p. 359
C_6H_6S	Phenylmercaptan: EtOH (161, 536†); NaOH, Vap. (161)
$C_6H_7BrN_2$	*p*-Bromophenylhydrazine: EtOH, HCl (40)
C_6H_7N	*α*-Picoline (14,† 506); P (509†); EtOH (312†); Vap. (312, 508)
C_6H_7N	*β*-Picoline (14†); EtOH, Vap. (312†)
C_6H_7N	Picoline (263); EtOH (262)
C_6H_7N	Aniline (37,‡ 38,‡ 530); P (510); H_2O (286†); EtOH (20, 286, 386,† 395, 410, 486†); hexane (354‡); HCl (20, 386†); NaOEt (386†); Vap. (202, 358, 486, 510, 658); *cf.* p. 359
C_6H_7NO	*m*-Aminophenol: EtOH, Vap. (519)
C_6H_7NO	*p*-Aminophenol: EtOH, EtOH + NaOH + Na_2SO_3, HCl (27)
C_6H_7NO	*α*-Methyl-*β*-pyridone (14)
$C_6H_7NO_2$	Pyrocinchonimide: H_2O, EtOH (389)
$C_6H_7N_3O_2$	Nitro-*m*-phenylenediamine: EtOH (218)
$C_6H_7N_3O_2$	Nitro-*p*-phenylenediamine: EtOH (477)
$C_6H_7N_3O_2$	*p*-Nitrophenylhydrazine: EtOH (40)
$C_6H_7N_3O_4$	Dimethylvioluric acid: EtOH (+HCl) (+KOEt) (+LiOEt) (+NaOEt) (251); Cs, K, Li, Na, Pb salts: phenol, benzene (251)
$C_6H_7N_3O_5$	Dimethylnitrobarbituric acid: H_2O, H_2SO_4, NaOH (255)
C_6H_8	Hexatriene (42, 423)
C_6H_8	$\Delta^{1,3}$-Cyclohexadiene (663); Vap. (599, 601)
C_6H_8	$\Delta^{1,4}$-Cyclohexadiene (663)
C_6H_8BrN	Pyridine methobromide: EtOH (223)
C_6H_8ClN	Pyridine methochloride: H_2O (223, 228, 241, 242); EtOH (223)
C_6H_8ClN	Aniline hydrochloride (395)
C_6H_8ClN	*α*-Picoline hydrochloride (506)
C_6H_8IN	Pyridine methiodide: H_2O (228, 242); EtOH, $CHCl_3$, $C_5H_{11}OH$ (223, 228)
$C_6H_8N_2$	Benzeneazomethane (247); EtOH (621); EtOH + $CHCl_3$ (40)
$C_6H_8N_2$	2, 5-Dimethylpyrazine: EtOH (279)
$C_6H_8N_2$	Phenylhydrazine: EtOH (40, 512†); HCl (40)
$C_6H_8N_2$	*o*(*m*)-Phenylenediamine (642)
$C_6H_8N_2$	*p*-Phenylenediamine: EtOH (521, 642); Vap. (521)
$C_6H_8O_2$	Dihydroresorcinol (176); Derivatives (27†)

Formula	Name, solvents and literature
	Ultra-violet and Visible.—(*Continued*)
$C_6H_8O_2$	1, 4-Diketohexamethylene: EtOH (273†)
$C_6H_8O_2$	Dimethyldiketotetramethylene (371‡); H_2O, EtOH (370‡)
$C_6H_8O_4$	Ethyl acetylglyoxylate (66‡)
$C_6H_8O_4$	Ethyl diketobutyrate (69‡)
$C_6H_8O_4$	Lactide: $CHCl_3$ (134)
$C_6H_8O_5$	Dimethyl oxaloacetate: H_2O, HCl, MeOH, EtOH, Et_2O, ligroin (237); Na salt: H_2O, Na_2CO_3, $NaOCH_3$ (237)
$C_6H_8O_6$	Tricarballylic acid (58,‡ 64‡); EtOH (607); *cf.* p. 359
$C_6H_8O_7$	Citric acid (58‡)
$C_6H_9N_3O_2$	Histidine: *v.* p. 359
$C_6H_9N_3O_3$	Trimethyl isocyanurate: H_2O (80)
C_6H_{10}	Cyclohexene (592.3, 663); P, Vap. (599); EtOH (279, 599)
C_6H_{10}	2, 4-Hexadiene: Vap. (601, 602)
C_6H_{10}	Diallyl: Vap. (602); *cf.* p. 359
C_6H_{10}	α, $\alpha(\beta, \gamma)$-Dimethylbutadiene: Vap. (602); *cf.* p. 359
$C_6H_{10}ClN_3O_2$	Histidine hydrochloride: 50% EtOH (649‡)
$C_6H_{16}N_2$	1, 3, 5 (and 3, 4, 5)-Trimethylpyrazole (554)
$C_6H_{10}O$	Mesityl oxide (66,‡ 67,‡ 68,‡ 69,‡ 176, 294, 574‡); H_2O (204‡); EtOH (82, 204,‡ 539); hexane (204,‡ 573‡); MeOH, $CaCl_2$ soln. (573‡); Vap. (539); *cf.* p. 360
$C_6H_{10}O$	Diethylketene: hexane (370,‡ 371‡); *cf.* p. 360
$C_6H_{10}O$	Cyclohexanone (66,‡ 176, 294)
$C_6H_{10}O$	Allylacetone (59,‡ 66,‡ 67,‡ 69‡); EtOH, Vap. (539)
$C_6H_{10}O_2$	Acetylmethylacetonic acid, vanadyl salt: EtOH (475)
$C_6H_{10}O_2$	Ethyl crotonate (68‡); EtOH (252); H_2O, hexane (204‡); *cf.* p. 360
$C_6H_{10}O_2$	Methylacetylacetone (24, 69,‡ 176); H_2O, hexane (204‡); EtOH (204,‡ 475, 478); *cf.* p. 360
$C_6H_{10}O_2$	Acetonylacetone (59,‡ 62,‡ 66‡); EtOH (23,† 609); alk. (609); *cf.* p. 360
$C_6H_{10}O_2S_2$	Diethyl dithiooxalate: EtOH (536)
$C_6H_{10}O_2S_3$	Xanthic thioanhydride: EtOH (252)
$C_6H_{10}O_3$	Ethyl acetoacetate (22, 59,‡ 62,‡ 68,‡ 255†); P (220); H_2O (33,† 220, 228, 609); EtOH (24, 33,† 220, 228, 478, 609); Et_2O (228); hexane (220, 228); ligroin (222); MeOH (228); alk. (22, 24, 220, 228, 294, 385); HCl (22, 220, 228); *cf.* p. 360; Al derivatives: EtOH (22)
$C_6H_{10}O_3$	β-Ethoxycrotonic acid and Na salt: EtOH (252)
$C_6H_{10}O_3S$	Diethyl thiooxalate: EtOH (536)
$C_6H_{10}O_4$	Diethyl oxalate: P, ligroin (252); EtOH (252, 536†)
$C_6H_{10}O_5$	Dilactylic acid: $CHCl_3$ (134)
$C_6H_{10}O_5$	Lactic anhydride: $CHCl_3$ (134)
$C_6H_{11}BrN_2O_2$	Bromural: *v.* p. 360
$C_6H_{11}NO_2$	α, α-Methylnitrocyclopentane: EtOH (553, 664)
$C_6H_{11}NO_2$	Nitrocyclohexane: EtOH, CH_3ONa (664)
$C_6H_{11}NO_2$	Nitrosoisopropylacetone (228); H_2O, EtOH (25)
$C_6H_{11}NO_2$	Cyclopentylnitromethane: EtOH, NaOEt (553)
$C_6H_{11}NO_2$	Ethyl β-aminocrotonate: EtOH, HCl (22)
C_6H_{12}	Cyclohexane (664); EtOH (279)
C_6H_{12}	Hexylene: Vap. (600)
C_6H_{12}	Methylcyclopentane: EtOH (664)
$C_6H_{12}O$	Methyl butyl ketone (59,‡ 62,‡ 545‡); P, H_2O, EtOH, heptane, $CHCl_3$ (546†)
$C_6H_{12}O$	Methyl isobutyl ketone (59,‡ 62,‡ 66,‡ 67,‡ 176, 294, 545‡); P, H_2O, EtOH, heptane, $CHCl_3$ (546†); *cf.* p. 360
$C_6H_{12}O$	Methyl *tert.*-butyl ketone (59,‡ 62,‡ 294, 545,‡ 601); EtOH (546,† 609); $CHCl_3$, heptane (546†)
$C_6H_{12}O$	Ethyl propyl ketone (59,‡ 62,‡ 545‡); P, H_2O, EtOH, heptane, $CHCl_3$ (546†)
$C_6H_{12}OS_2$	Ethyl ethylthiolthioacetate: EtOH (536†)
$C_6H_{12}O_2$	Butyl acetate (54,‡ 55,‡ 56,‡ 57‡)
$C_6H_{12}O_2$	Ethyl butyrate (55,‡ 57,‡ 60‡)
$C_6H_{12}O_2$	Propyl propionate (60‡)
$C_6H_{12}O_2$	Methyl valerate (55,‡ 57,‡ 60‡)
$C_6H_{12}O_2S$	Ethyl ethylthiolacetate: EtOH (536†)
$C_6H_{12}O_3$	Paraldehyde (534,† 571); *cf.* p. 360
$C_6H_{12}O_6$	Levulose: H_2O (532)
$C_6H_{12}O_6$	Dextrose (265,† 594); H_2O (532)
$C_6H_{12}S_3$	Trithioacetaldehyde (534†)
$C_6H_{13}ClN_2O_4S_2$	Cystine hydrochloride: 50% EtOH (649‡)
$C_6H_{13}NO_2$	Leucine (594†); *cf.* p. 360
$C_6H_{14}N_2$	$\beta(\gamma)$-Dimethylpiperazine: EtOH,† Vap. (520)
$C_6H_{14}N_2O_2$	Lysine: *v.* p. 360
$C_6H_{14}N_4O_2$	Arginine: *v.* p. 360
$C_6H_{14}O$	Hexyl alcohol (438)
$C_6H_{14}O$	Methyl *n*-amyl ether (592.3)
$C_6H_{14}O_2$	Acetal (534†)
$C_6H_{14}S_2$	*S*-Diethylthioethane: EtOH (536)
$C_6H_{15}IS$	Triethylsulfonium iodide: $CHCl_3$, EtOH (242)
$C_6H_{15}N$	Triethylamine (63,‡ 395†)
$C_6H_{15}N$	Dipropylamine (63‡)
$C_6H_{16}ClN$	Triethylamine hydrochloride (395†)
$C_7H_2Br_3N_3$	Tribromobenzene-*anti*(*syn*)-diazonium cyanide: Et_2O (247)
$C_7H_3Cl_2NO_2$	Quinolinyl chloride: Et_2O (578)
$C_7H_3Cl_3O_2$	Trichlorotoluquinone: EtOH (610)
$C_7H_4ClN_3$	*p*-Chlorobenzenediazonium cyanide (147)
$C_7H_4Cl_2O_3S$	*o*-Sulfobenzoic acid dichloride: Et_2O (578)
$C_7H_4Cl_3NO_2$	Methyl 2, 3, 4-trichloropicolinic acid (506)
$C_7H_4O_6$	Chelidonic acid, Na salts: H_2O (21)
$C_7H_5BrN_2O_4$	Phenylbromodinitromethane: EtOH (198)
$C_7H_5BrO_2$	*p*-Bromobenzoic acid and Na salt: EtOH, NaOH (317)
$C_7H_5Br_3O$	Tribromophenyl methyl ether: EtOH, HCl (406)
C_7H_5ClO	Benzoyl chloride: EtOH (523)
C_7H_5ClO	*o*(*m*, *p*)-Chlorobenzaldehyde: EtOH, Vap. (523)
$C_7H_5ClO_2$	*o*(*m*)-Chlorobenzoic acid (527); EtOH (576)
$C_7H_5ClO_2$	*p*-Chlorobenzoic acid (527)
$C_7H_5Cl_2N_3O_2$	3, 5-Dichloro-4-hydroxybenzeneazoformamide: EtOH, NaOH (293)
$C_7H_5Cl_3$	Benzotrichloride (642)
$C_7H_5IO_2$	*o*(*m*, *p*)-Iodobenzoic acid (527)
C_7H_5N	Benzonitrile (20, 37,‡ 530); EtOH (524); Vap. (524, 624)
C_7H_5NO	Phenyl isocyanate: hexane (370,‡ 371‡)
C_7H_5NO	Anthranil: EtOH, Et_2O, hexane (575)
$C_7H_5NO_2$	*o*-Oxycarbanil (479‡); EtOH (283)
$C_7H_5NO_3$	*o*(*m*, *p*)-Nitrobenzaldehyde (640); EtOH, Vap. (540)

Formula	Name, solvents and literature
	Ultra-violet and Visible.—(*Continued*)
$C_7H_5NO_3S$	Saccharin: H_2O (134)
$C_7H_5NO_4$	Quinolinic acid: H_2O (394); EtOH (262, 578); *cf.* p. 360
$C_7H_5NO_4$	Lutidinic acid (262)
$C_7H_5NO_4$	*o*(*m*)-Nitrobenzoic acid (527)
$C_7H_5NO_4$	*p*-Nitrobenzoic acid (527); EtOH, NaOH (317)
$C_7H_5N_3O_7$	2, 4, 6-Trinitroanisole: EtOH (34, 86); various solns. (34)
$C_7H_5N_5O_8$	Picrylmethylnitroamine: EtOH, KOH (165)
$C_7H_6ClNO_2$	Chlorotoluquinone oxime: EtOH (217); K salt: EtOH + KOH (217)
$C_7H_6ClN_3O_2$	3-Chloro-4-hydroxybenzeneazoformamide: EtOH, EtOH + NaOH (293)
$C_7H_6Cl_2$	Benzylidine chloride (642); EtOH, Vap. (523)
$C_7H_6N_2$	Phenyldiazomethane: *v.* p. 360
$C_7H_6N_2O_3$	*p*-Nitro-*anti*(*syn*)-benzaldoxime: EtOH (80, 217); NaOEt (80)
$C_7H_6N_2O_4$	Phenyldinitromethane: EtOH, $CHCl_3$ (259, 291); K salt: H_2O (198, 259, 291)
$C_7H_6N_2O_4$	*o*(*m*, *p*)-Nitrophenylnitromethane: EtOH, $CHCl_3$ (291); K salt: H_2O (291)
$C_7H_6N_4O_5$	3, 5-Dinitro-*p*-tolylnitrosoamine: EtOH (471, 472)
$C_7H_6N_4O_6$	Picrylmethylamide: EtOH, KOH (165)
$C_7H_6N_4O_7$	2, 3, 5-Trinitroaminoanisole (453)
C_7H_6O	Benzaldehyde (37,‡ 38,‡ 66,‡ 534, 637); EtOH (20, 540, 604,‡ 636†); EtOH, HCl, $CHCl_3$ (636†); Vap. (540, 624); *cf.* p. 360
C_7H_6OS	Thiobenzoic acid: H_2O, EtOH (252); Hg, K salts: EtOH (252)
$C_7H_6O_2$	*o*-Hydroxybenzaldehyde (38,‡ 637); EtOH (39,† 523, 634, 636,† 638); H_2O, HCl, $CHCl_3$ (636†); NaOEt (634); Vap. (523)
$C_7H_6O_2$	*m*-Hydroxybenzaldehyde (636, 638); H_2O, HCl (636†); EtOH (523, 636†); Vap. (523)
$C_7H_6O_2$	*p*-Hydroxybenzaldehyde (636, 638); H_2O, HCl (636); EtOH (523, 634, 636); NaOEt (634); Vap. (523)
$C_7H_6O_2$	Benzoic acid (182,‡ 527, 645.5†); H_2O (286); EtOH (136, 238, 285, 317, 384, 457); hexane (95,‡ 96,‡ 606‡); H_2SO_4 (238); NaOH (317); Vap. (624); *cf.* p. 360; Ag, K salts: H_2O (285); Na salts: H_2O (182,‡ 659†)
$C_7H_6O_2$	Toluquinone (36); EtOH (409, 410); Vap. (531); *cf.* p. 360
$C_7H_6O_3$	Salicylic acid: H_2O (182,‡ 286, 427, 429, 659†); EtOH (267, 384, 386); hexane + Et_2O (96‡); Na salt: H_2O (182,‡ 659,† 660†); EtOH (386); *cf.* p. 360
$C_7H_6O_3$	*m*-Hydroxybenzoic acid: H_2O (427, 429); EtOH (267, 386); hexane + Et_2O (96‡); *cf.* p. 360
$C_7H_6O_3$	*p*-Hydroxybenzoic acid: H_2O (286, 427, 429); EtOH, (267, 386); hexane + Et_2O (96‡); *cf.* p. 360; Na salt (660†); EtOH (386)
$C_7H_6O_5S$	*o*-Sulfobenzoic acid: EtOH (578); NH_4 salt: H_2O (134)
C_7H_7Br	*o*(*m*)-Bromotoluene: P, EtOH, Vap. (515)
C_7H_7BrO	*p*-Bromoanisole: EtOH, Vap. (526)
C_7H_7Cl	Benzyl chloride (642); EtOH, Vap. (524)
C_7H_7Cl	*o*-Chlorotoluene (17, 386†); P,† Vap. (515); EtOH (28, 515†)
C_7H_7Cl	*m*-Chlorotoluene (17); P,† Vap. (515); EtOH (28, 515†)
C_7H_7Cl	*p*-Chlorotoluene (17, 386†); EtOH (28)
C_7H_7ClS	*p*-Chlorobenzylmercaptan: ligroin (212‡)
$C_7H_7Cl_2NO_2S$	Toluene-*p*-sulfonedichloramide: EtOH (199)
C_7H_7I	*o*(*m*)-Iodotoluene: P,† EtOH,† Vap. (517)
C_7H_7NO	Benzamide: EtOH (285)
C_7H_7NO	*o*-Aminobenzaldehyde: EtOH, EtOH + HCl (30)
C_7H_7NO	*p*-Aminobenzaldehyde: EtOH (30, 519); EtOH + HCl (30); Vap. (519)
C_7H_7NO	*anti*(*syn*)-Benzaldoxime (637, 639, 642); EtOH (80, 523); NaOEt (80); Et_2O (278); Vap. (523)
$C_7H_7NO_2$	*o*(*m*, *p*)-Nitrotoluene: Vap. (540); EtOH (43, 637)
$C_7H_7NO_2$	Phenylnitromethane (228, 664); EtOH, Et_2O, MeOEt (255)
$C_7H_7NO_2$	*o*(*m*, *p*)-Aminobenzoic acid (428†); H_2O (429)
$C_7H_7NO_3$	*o*-Nitroanisole (540, 637); EtOH (26, 32, 43); H_2SO_4 (32); ligroin (43); Vap. (540)
$C_7H_7NO_3$	*m*-Nitroanisole (637)
$C_7H_7NO_3$	*p*-Nitroanisole (26, 637); EtOH (26, 32); H_2SO_4 (32); Vap. (540)
$C_7H_7NO_3$	Nitro-*p*-cresol: EtOH (+NaOEt) (43)
C_7H_7NS	Thiobenzamide: H_2O (252)
$C_7H_7N_3O$	Phenylazocarbamide (247)
$C_7H_7N_3O_2$	Quinonemonosemicarbazone: EtOH (+NaOH) (293)
$C_7H_7N_3O_3$	*p*-Nitrobenzenemethylnitrosoamine: EtOH (247)
$C_7H_7N_3O_3$	*p*-Nitrobenzenediazonium hydroxide methyl ether (247)
$C_7H_7N_3O_4$	2, 4-Dinitromethylaniline: EtOH (477)
$C_7H_7N_3O_4$	Dinitro-*o*(*m*)-toluidine: EtOH (477)
$C_7H_7N_3O_4$	2(3), 6(5)-Dinitro-*p*-toluidine: EtOH (472)
$C_7H_7N_3O_5$	2, 6-Dinitro-4-aminoanisole: EtOH, HCl (453)
C_7H_8	Toluene (20,† 37,‡ 133, 202,† 530, 642); P (486, 515†); EtOH (386,† 443,† 483.5, 486); hexane (353,‡ 355‡); Vap. (111, 202, 271, 483.5, 486, 647, 658); *cf.* p. 360
C_7H_8ClN	Chlorolutidine (504)
$C_7H_8ClNO_2S$	Toluene-*p*-sulfonechloramide: EtOH (199)
$C_7H_8N_2$	Formaldehyde phenylhydrazone: EtOH (40)
$C_7H_8N_2O$	*o*-Aminobenzaldoxime: EtOH + HCl (30)
$C_7H_8N_2O$	Phenylmethylnitrosoamine (147); EtOH (25)
$C_7H_8N_2OS$	Thionylmethylphenylhydrazine: EtOH (334)
$C_7H_8N_2O_2$	3-Nitro-*p*-toluidine: EtOH (43)
$C_7H_8N_2O_2$	Nitrotoluidine (*9 forms*): EtOH (477)
$C_7H_8N_2O_4S$	Nitrotoluene-*p*-sulfonamide: EtOH (+NaOEt) (199)
$C_7H_8N_4O_2$	Theobromine (129,† 269†); *cf.* p. 360
$C_7H_8N_4O_2$	Theophylline (129†); *cf.* p. 360
C_7H_8O	Benzyl alcohol (20,† 37,‡ 642); H_2O, C_6H_5OH (350); Vap. (524, 624)
C_7H_8O	Anisole (20, 37,‡ 150,† 636†); EtOH (27, 32, 386,† 526†); H_2SO_4 (32); $CHCl_3$ (537); Vap. (526,† 537)
C_7H_8O	*o*-Cresol (660†); P,† Vap. (540); EtOH (27, 220, 267); alk. (27, 220); hexane (355‡); *cf.* p. 360; Na salt: H_2O (660†)
C_7H_8O	*m*-Cresol: EtOH (267); (+NaOH) (27); Vap. (540); *cf.* p. 360
C_7H_8O	*p*-Cresol (660†); P,† Vap. (540); EtOH (27, 267); (+NaOH) (27); hexane (355‡); *cf.* p. 360; Na salt: H_2O (660†)

Formula	Name, solvents and literature
	Ultra-violet and Visible.—(*Continued*)
C_7H_8OS	Ketothiodimethylpyrone: EtOH, Et_2O, H_2SO_4 (241)
$C_7H_8O_2$	Dimethylpyrone (76); EtOH (21, 76, 241); NaOH, HCl (21)
$C_7H_8O_2$	Guaiacol: P,† Vap. (540); H_2O (636,† 638, 660†); EtOH (27, 636,† 638); (+NaOH) (27)
$C_7H_8O_2$	Resorcinol monomethyl ether (27†); H_2O, EtOH (636†)
$C_7H_8O_2$	Hydroquinol methyl ether (27†)
$C_7H_8O_2S$	Phenylmethylsulfone: EtOH (189)
$C_7H_8O_3S$	Toluene-*o*-sulfonic acid: H_2O (578)
$C_7H_8O_4S$	Hydroxybenzylsulfonic acid: EtOH (523†)
C_7H_9N	Benzylamine (642); P, EtOH, Vap. (510)
C_7H_9N	*o*-Toluidine (386†); P, Vap. (510); EtOH (263†); EtOH + acid (28); hexane (354‡); *cf.* p. 360
C_7H_9N	*m*-Toluidine (386†); P, Vap. (510); EtOH (+acid) (28); *cf.* p. 360
C_7H_9N	*p*-Toluidine (507); acid (28, 263†); hexane (354‡); *cf.* p. 360
C_7H_9N	Methylaniline: P, Vap. (510); EtOH (20)
C_7H_9N	2, 4-Lutidine: Vap. (508)
C_7H_9N	2, 6-Lutidine (14); Vap. (508)
C_7H_9NO	γ-Lutidone: EtOH (+HCl) (+NaOEt) (14)
C_7H_9NO	*o*(*p*)-Anisidine: EtOH (+HCl) (27, 386†); Vap. (526)
$C_7H_9NO_2S$	*p*-Toluenesulfoneamide: EtOH (199)
$C_7H_9N_3O_2$	4-Nitro-2, 5-tolylenediamine: EtOH (477)
$C_7H_{10}BrNO_6$	Diethyl bromonitromalonate: EtOH (198, 255)
$C_7H_{10}Br_2O_4$	Diethyl dibromomalonate: EtOH (198)
$C_7H_{10}ClN$	*o*(*p*)-Toluidine hydrochloride: EtOH (263)
$C_7H_{10}ClN$	2, 6-Lutidine hydrochloride (14)
$C_7H_{10}INO$	Pyridonium ethiodide: H_2O, $CHCl_3$ (242)
$C_7H_{10}N_2O_2$	Methylaminomethylmaleinmethylimide: EtOH, HCl (389)
$C_7H_{10}N_2O_4$	Diethyl diazomalonate: *v.* p. 360
$C_7H_{10}O_3$	Diacetylacetone: H_2O, EtOH, alk. (21)
$C_7H_{10}O_6S$	Dimethylpyrone sulfate: H_2SO_4 (241)
$C_7H_{11}BrO_4$	Diethyl bromomalonate: EtOH (198)
$C_7H_{11}ClO_4$	Diethyl chloromalonate: EtOH (198)
$C_7H_{11}N$	1, 2, 5-Trimethylpyrrole (362)
$C_7H_{11}NO_5$	Diethyl isonitrosomalonate: EtOH (+alk.) (31)
$C_7H_{11}NO_6$	Diethyl nitromalonate: EtOH (198, 255); H_2O, H_2SO_4, CH_3OH, $CHCl_3$, Et_2O (255)
$C_7H_{12}O$	Suberone: *v.* p. 360
$C_7H_{12}O$	*o*(*p*)-Methylcyclohexanone (294)
$C_7H_{12}O$	*m*-Methylcyclohexanone (176, 294)
$C_7H_{12}O_2$	Dimethylacetylacetone (176)
$C_7H_{12}O_2S_2$	Diethyl dithiomalonate: EtOH (536†)
$C_7H_{12}O_3$	Ethyl methylacetoacetate: EtOH, hexane, NaOEt, H_2O (220)
$C_7H_{12}O_3$	Ethyl levulinate (66,‡ 67,‡ 68‡); EtOH (609)
$C_7H_{12}O_6$	Quinic acid: *v.* p. 360
$C_7H_{13}BrN_2O_2$	Adaline: *v.* p. 360
$C_7H_{13}NO_2$	Piperidylacetic acid (395,† 398‡); Cu salt: EtOH (391)
$C_7H_{13}NO_2$	α, α-Methylnitrocyclohexane: EtOH (664)
$C_7H_{13}N_3O$	α, β-Mesityl semicarbazone (656)
C_7H_{14}	Methylcyclohexane: EtOH (664)
$C_7H_{14}O$	Methyl amyl ketone (176)
$C_7H_{14}O$	Dipropyl ketone (59,‡ 62,‡ 176, 294, 545‡)
$C_7H_{14}O$	Diisopropyl ketone (294, 545‡)
$C_7H_{14}O$	Ethyl isobutyl ketone (176, 545‡)
$C_7H_{14}O_2$	Propyl butyrate (60‡)
$C_7H_{14}O_2$	Amyl acetate: P, ligroin, EtOH (252)
$C_7H_{16}O$	Heptyl alcohol (438†)
$C_7H_{16}O_3$	Ethyl orthoformate and salts (240, 252); K salt: H_2O (252)
$C_8H_4Cl_2O_2$	Phthalyl chloride: Et_2O, hexane (577)
$C_8H_4Cl_2O_6$	*p*-Dichlorodioxyterephthalic acid: H_2O, EtOH, Et_2O, HCl (236)
$C_8H_4O_3$	Phthalic anhydride: EtOH (284); AcOH, H_2SO_4 (500)
$C_8H_5NO_2$	Isatin (36,† 479,‡ 648‡); EtOH (275); various solvents (435‡)
$C_8H_5NO_2$	*o*(*m*)-Cyanobenzoic acid: EtOH, NaOEt (576)
$C_8H_5NO_2$	Phthalimide (386†); EtOH (284, 500); H_2SO_4 (500)
$C_8H_5NO_3$	Anthroxanic acid: EtOH, Et_2O, HCl (575)
$C_8H_5NO_3$	Phthaloxime (500)
C_8H_6	Phenylacetylene (423, 619); EtOH (386)
$C_8H_6N_2O_2$	*p*-Nitrobenzyl cyanide and K, Na salts: EtOH (405); K, Na salts: EtOH, MeOH (405)
$C_8H_6N_2O_2$	*p*-Nitrophenylacetonitrile: EtOH, NaOH (317)
$C_8H_6N_2O_2$	Nitrosophthalimide: EtOH, NaOEt (500)
$C_8H_6N_2O_2$	Phenylcyanonitromethane: EtOH (255); Na salt: H_2O (255)
$C_8H_6N_4O_8$	Alloxantin: H_2O (269†)
$C_8H_6N_4O_8$	2, 3, 5-Trinitro-4-acetylaminophenol: EtOH (+alk.) (455)
$C_8H_6O_2$	*o*(*m*, *p*)-Phthalic aldehyde (640); EtOH, Vap. (523)
$C_8H_6O_2$	Phthalide (386); EtOH, H_2SO_4, NaOH (500)
$C_8H_6O_3$	Piperonal: EtOH, Vap. (533)
$C_8H_6O_4$	Phthalic acid (386†); H_2O (284, 286, 429); EtOH, H_2SO_4 (500)
$C_8H_6O_4$	Isophthalic acid: H_2O (429); EtOH (284); K salt: H_2O (284)
$C_8H_6O_4$	Terephthalic acid (284); H_2O (429); K salt (284)
$C_8H_6O_4$	Piperonylic acid (287); EtOH (140, 533); Vap. (533)
$C_8H_6O_6$	Dihydroxyterephthalic acid: MeOH (236)
C_8H_7Cl	α(ω)-Chlorostyrene: EtOH (393)
$C_8H_7ClS_3$	*p*-Chlorobenzyltrithiocarbonic acid: ligroin (212); K salt: H_2O (212)
C_8H_7N	Indole (648‡); hexane (171‡); *v.* p. 360
C_8H_7N	Phenylacetonitrile (37‡); EtOH (317, 524); NaOH (317); Vap. (524)
C_8H_7N	*o*(*p*)-Tolunitrile (386†); EtOH (28, 524); Vap. (524)
C_8H_7N	*m*-Tolunitrile: EtOH (28, 524); Vap. (524)
C_8H_7NO	Phthalimidine: EtOH, H_2SO_4 (500)
C_8H_7NO	Mandelonitrile: EtOH (523†)
C_8H_7NO	Methylanthranil: H_2O, HCl (+ EtOH), Et_2O, hexane (575)
$C_8H_7NO_2$	α, β-Dioxindol (648‡)
$C_8H_7NO_2$	ω-Nitrostyrene: EtOH (25)
$C_8H_7NO_4$	*p*-Nitrophenylacetic acid: EtOH (+ NaOH) (317)
$C_8H_7NO_4$	*o*(*p*)-Acetoxynitrobenzene (637)
$C_8H_7N_3O$	Anisole-*anti*(*syn*)-diazonium cyanide (147); H_2O + HCN (247)
$C_8H_7N_3O_6$	3, 4, 5(6)-Trinitro-*o*-xylene: EtOH (43)
$C_8H_7N_3O_6$	3, 5-Dinitro-4-aminophenyl acetate: EtOH (+KOH) (454)
$C_8H_7N_3O_6$	3, 5-Dinitro-4-acetylaminophenol: EtOH (454)

Formula	Name, solvents and literature
	Ultra-violet and Visible.—(*Continued*)
C_8H_8	Styrene: EtOH (25, 383, 384, 386, 393, 423, 619)
$C_8H_8BrN_3O_2$	5-Bromo-4-hydroxy-*m*-tolueneazoformamide: EtOH (+NaOH) (293)
C_8H_8ClNO	Acetylchloroaminobenzene: H_2O (497.5)
C_8H_8ClNO	Chloroacetanilide: EtOH (199)
C_8H_8ClNO	*p*-Chloroacetanilide (497.5)
$C_8H_8N_2O_2$	Nitrosoacetanilide: Et_2O (247)
$C_8H_8N_2O_3$	*p*-Nitrobenzaldoxime methyl ether (*four forms*): EtOH (80)
$C_8H_8N_2O_4$	3, 4(5)-Dinitro-*o*-xylene: EtOH (43)
$C_8H_8N_2O_4$	4, 5-Dinitro-*o*-xylene: EtOH (43)
$C_8H_8N_2O_5$	2, 4-Dinitrophenetole: H_2O (86)
$C_8H_8N_4O_5$	2, 5-Dinitro-*p*-tolylmethylnitrosoamine: EtOH (471, 472)
$C_8H_8N_4O_6$	3, 5-Dinitro-*p*-tolylmethylnitroamine: EtOH (471, 472)
$C_8H_8N_6O_6$	Murexide: H_2O (269,† 402)
C_8H_8O	Acetophenone (37,‡ 66,‡ 540, 636, 637, 642); EtOH (20); $CHCl_3$ (392)
C_8H_8O	*o*(*m*, *p*)-Toluic aldehyde: EtOH, Vap. (523)
$C_8H_8O_2$	Methyl benzoate: EtOH (119)
$C_8H_8O_2$	Phenyl acetate (76, 636†)
$C_8H_8O_2$	Phenylacetic acid (20, 37,‡ 527); H_2O (659†); *cf.* p. 360; Na salt: EtOH + NaOH (317, 386); H_2O (386, 659†)
$C_8H_8O_2$	*o*(*m*, *p*)-Toluic acid (487, 527)
$C_8H_8O_2$	*ψ*, *m*-Toluic acid (487)
$C_8H_8O_2$	*p*-Xyloquinone (36); EtOH (409, 410); Vap. (531)
$C_8H_8O_2$	*o*-Methoxybenzaldehyde (636,† 637); EtOH (634, 636); EtOH + HCl (636†)
$C_8H_8O_2$	*m*-Methoxybenzaldehyde: EtOH (+HCl) (636†)
$C_8H_8O_2$	*p*-Methoxybenzaldehyde: EtOH (523, 634, 636†); (+HCl) (636†)
$C_8H_8O_3$	Mandelic acid (527); EtOH (386)
$C_8H_8O_3$	Piperonyl alcohol: EtOH, Vap. (533)
$C_8H_8O_3$	Vanillin: EtOH (523, 606‡); H_2O, Et_2O (606‡); hexane (604,‡ 606‡); Vap. (523); *cf.* p. 360
$C_8H_8O_3$	Methyl *o*-hydroxybenzoate: EtOH (386)
$C_8H_8O_3$	*o*(*p*)-Methoxybenzoic acid and Na salts: EtOH (386)
$C_8H_8O_3$	Phenoxyacetic acid: EtOH (+NaOEt) (386†)
$C_8H_8O_4$	Dehydracetic acid: EtOH (+NaOEt) (21)
$C_8H_8O_4$	Isodehydracetic acid: EtOH (21)
$C_8H_8O_4$	Dimethylpyronecarboxylic acid: EtOH (21)
$C_8H_8O_5$	Hematinic acid anhydride (481‡); Et_2O (171‡); *cf.* p. 360
$C_8H_9BrN_2$	Acetaldehyde *p*-bromophenylhydrazone: EtOH (40)
C_8H_9BrO	*p*-Bromophenetole: Vap. (526)
C_8H_9FO	*p*-Fluorophenetole: EtOH, Vap. (526)
C_8H_9NO	Acetanilide (199, 641); EtOH (43, 119)
C_8H_9NO	Acetophenoneoxime: EtOH (119)
C_8H_9NO	*o*(*p*)-Aminoacetophenone: EtOH (+HCl) (30)
C_8H_9NO	Benz-*anti*-aldoxime *N*(*O*)-methyl ether: EtOH (80)
$C_8H_9NO_2$	Methylanthranilic acid: EtOH (395)
$C_8H_9NO_2$	Anilinoacetic acid: EtOH (391); Cu, Na salts: H_2O (391)
$C_8H_9NO_2$	3(4)-Nitro-*o*-xylene: EtOH, ligroin (43)
$C_8H_9NO_2$	Phenylaminoacetic acid and K salt: EtOH (386)
$C_8H_9NO_3$	*o*(*m*, *p*)-Nitrophenetole: EtOH, ligroin (43)
$C_8H_9NO_3$	Nitro-*p*-cresetole: EtOH (43)
$C_8H_9NO_4$	Nitroquinol dimethyl ether: H_2O, hexane (254); EtOH (32, 43); aniline, pyridine, ligroin, C_6H_6 (43); $CHCl_3$ (43, 254); H_2SO_4 (32)
$C_8H_9NO_4$	Hematinic acid imide: Et_2O (171‡); *cf.* p. 360
$C_8H_9NO_4$	Ethyl citrazinate: EtOH (+NaOEt) (14)
C_8H_9NS	Thioacetanilide and Na salt (445)
$C_8H_9N_3O_2$	4-Hydroxy-*m*-tolueneazoformamide: EtOH (+NaOH) (293)
$C_8H_9N_3O_3$	2-Nitro-4-acetyl-*p*-phenylenediamine: EtOH (477)
$C_8H_9N_3O_4$	3, 4-Dinitro-5-amino-*o*-xylene: EtOH (472)
$C_8H_9N_3O_4$	3, 5-Dinitro-4(6)-amino-*o*-xylene (477); EtOH (472)
$C_8H_9N_3O_4$	4(6), 5-Dinitro-3-amino-*o*-xylene: EtOH (472)
$C_8H_9N_3O_4$	2, 4-Dinitrodimethylaniline: EtOH (218, 477)
$C_8H_9N_3O_4$	3, 4-Dinitrodimethylaniline: EtOH (218)
$C_8H_9N_3O_4$	2, 3-Dinitromethyl-*p*-toluidine: EtOH (471)
$C_8H_9N_3O_4$	3, 5-Dinitromethyl-*p*-toluidine (472)
C_8H_{10}	*o*(*m*, *p*)-Xylene (37‡); EtOH (27, 133, 263,† 379, 486); hexane (353‡); Vap. (202,† 271, 469, 486); *cf.* p. 360
C_8H_{10}	Ethylbenzene (20, 386, 423); EtOH (286, 486,† 619, 651†); Vap. (202, 271, 486, 651)
C_8H_{10}	Dimethylfulvene: Vap. (602)
$C_8H_{10}BrClO_2$	4-Bromo-4-chloro-1, 1-dimethylcyclohexan-3, 5-dione: EtOH (199)
$C_8H_{10}Br_2O_2$	Dibromothymoquinone: EtOH (610); Vap. (531)
$C_8H_{10}Br_2O_2$	4-Dibromo-1, 1-dimethylcyclohexan-3, 5-dione: EtOH (199)
$C_8H_{10}ClN$	*α*-Chlorocollidine (504, 535†)
$C_8H_{10}Cl_2O_2$	4-Dichloro-1, 1-dimethylcyclohexan-3, 5-dione: EtOH (199)
$C_8H_{10}N_2$	Acetaldehyde phenylhydrazone: EtOH (40, 620); AcOH (40)
$C_8H_{10}N_2$	Benzeneazoethane: EtOH (247, 620, 621)
$C_8H_{10}N_2O$	Nitrosodimethylaniline: EtOH (268)
$C_8H_{10}N_2O_2$	3-Nitromethyl-*p*-toluidine: EtOH (43, 472)
$C_8H_{10}N_2O_2$	5(6)-Nitro-4-amino-*m*-xylene: EtOH (477)
$C_8H_{10}N_2O_2$	*m*(*p*)-Nitrodimethylaniline: EtOH (43)
$C_8H_{10}N_4O_2$	Caffeine (129†); H_2O (264, 269†); *cf.* p. 360
$C_8H_{10}O$	*o*(*m*)-Cresol methyl ether: EtOH (27)
$C_8H_{10}O$	Phenetole (20); EtOH (27, 526); Vap. (526)
$C_8H_{10}O$	*m*, 4-Xylenol: EtOH (+NaOEt) (385, 533); Vap. (533)
$C_8H_{10}O$	*p*-Xylenol: EtOH (+NaOEt) (385)
$C_8H_{10}O_2$	4-Hydroxy-3-methoxytoluene (137)
$C_8H_{10}O_2$	Quinol dimethyl ether (32); EtOH (27, 638); H_2SO_4 (27)
$C_8H_{10}O_2$	Resorcinol dimethyl ether (27,† 636); EtOH, H_2SO_4 (32)
$C_8H_{10}O_2$	*o*-Dimethoxybenzene (Veratrole) (27†); hexane (604,‡ 606‡); *cf.* p. 360
$C_8H_{10}O_3$	Triacetic lactone ethyl ether: EtOH (21)
$C_8H_{10}O_4$	Diethyl acetylenedicarboxylate (58‡)
$C_8H_{11}BrO_2$	4-Bromo-1, 1-dimethylcyclohexan-3, 5-dione: EtOH (199)
$C_8H_{11}ClO_2$	4-Chloro-1, 1-dimethylcyclohexan-3, 5-dione: EtOH, NaOEt (199)

Formula	Name, solvents and literature
	Ultra-violet and Visible.—*(Continued)*
$C_8H_{11}ClO_5$	Trimethylpyroxonium perchlorate: H_2SO_4 (241)
$C_8H_{11}ClO_5S$	Dimethyl-2, 6-mercapto-4-pyroxonium perchlorate: H_2SO_4 (241)
$C_8H_{11}ClO_6$	Methoxy-4-dimethyl-2, 6-pyroxonium perchlorate: H_2SO_4 (241)
$C_8H_{11}ClO_6$	Dimethylmethoxypyroxonium perchlorate: H_2SO_4 (242)
$C_8H_{11}IO_2$	Dimethylmethoxypyroxonium iodide: H_2O, $CHCl_3$ (242)
$C_8H_{11}N$	3-*o*-Xylidine: P, EtOH, Vap. (510)
$C_8H_{11}N$	2-*m*-Xylidine: P, EtOH, Vap. (510)
$C_8H_{11}N$	4-*m*-Xylidine (507)
$C_8H_{11}N$	Collidine (504, 535); Vap. (508)
$C_8H_{11}N$	Ethylaniline (37‡); P, EtOH, Vap. (510)
$C_8H_{11}N$	Dimethylaniline (386); P, Vap. (510); EtOH (20, 384)
$C_8H_{11}NO$	*o(p)*-Phenetidine: EtOH, Vap. (526)
$C_8H_{11}NO$	*m*-Dimethylaminophenol: EtOH, Vap. (519)
$C_8H_{11}NO_3$	Isonitrosodimethyldihydroresorcinol, and Na salt: EtOH (400)
$C_8H_{12}ClN$	Dimethylaniline hydrochloride: EtOH (384)
$C_8H_{12}ClN$	Collidine hydrochloride (504)
$C_8H_{12}N_2O_3$	Veronal: *v.* p. 360
$C_8H_{12}N_4$	Azoisobutyronitrile (247)
$C_8H_{12}O_2$	Dimethyldihydroresorcinol: EtOH (+alk.) (27)
$C_8H_{12}O_2$	1, 1-Dimethylcyclohexan-3, 5-dione (176); EtOH (+NaOEt) (199)
$C_8H_{12}O_3$	Ethyl β-acetylcrotonate: H_2O, hexane (204‡)
$C_8H_{12}O_4$	Ethyl acetoacetylacetate: EtOH (+NaOEt) (21)
$C_8H_{12}O_5$	Ethyl oxaloacetate: EtOH (+alk.) (23†); hexane, NaOH (370,‡ 371‡); Na salt: H_2O + Na_2CO_3, $CHCl_3$ (237)
$C_8H_{13}NO$	Tropinone: *v.* p. 360
$C_8H_{13}NO_2$	Aminodimethyldihydroresorcinol: EtOH (27)
$C_8H_{13}NO_6$	Diethyl nitroisosuccinate: EtOH (198)
$C_8H_{13}NO_6$	Diethyl nitromethylmalonate: EtOH, $CHCl_3$ (255)
$C_8H_{14}Br_2O_3$	Ethyl β-ethoxycrotonate dibromide: EtOH (235)
$C_8H_{14}O$	Methylheptenone (66,‡ 67,‡ 176, 294); *cf.* p. 360
$C_8H_{14}O$	Dipropylketene: hexane (370,‡ 371‡)
$C_8H_{14}O_2S_2$	Dipropyl dithiooxalate: EtOH (536)
$C_8H_{14}O_2S_2$	Diethyl dithiosuccinate: EtOH (536†)
$C_8H_{14}O_3$	Ethyl ethylacetoacetate (59,‡ 68‡): EtOH (22, 59‡)
$C_8H_{14}O_3$	Ethyl β-ethoxycrotonate (22, 228, 255†); H_2O, hexane, NaOEt (220); EtOH (220, 226, 235, 385); *cf.* p. 360
$C_8H_{14}O_3$	Ethyl dimethylacetoacetate (228); EtOH (220, 226, 235); hexane (220)
$C_8H_{15}NO$	Tropine: *v.* p. 360
$C_8H_{16}O$	Methyl hexyl ketone (59,‡ 62,‡ 294, 545‡); EtOH (609)
$C_8H_{16}O$	Pentamethylacetone (294)
$C_8H_{17}N$	Coniine: P, EtOH, Vap. (509)
C_8H_{18}	Octane (286†)
$C_8H_{18}O$	*n*-Octyl alcohol (438†)
$C_8H_{18}O$	Isooctyl alcohol (261†)
$C_8H_{20}IP$	Tetraethylphosphonium iodide: H_2O, EtOH, $CHCl_3$, amyl alcohol (242)
$C_9H_5BrN_2O_3$	*p*-Bromophenyloximidooxazolone: Et_2O (243); metallic salts: $CHCl_3$, C_5H_5N, PhOH (243); Ba, Cs, K, Li, Na, NH_4, Rb salts: EtOAc + Me_2CO (243)
$C_9H_5Br_2NO$	5, 7-Dibromo-8-hydroxyquinoline: EtOH (+NaOH) (158)
$C_9H_5N_3O_{10}$	Trinitrophenylmalonic acid, K salt: H_2O, EtOH (249)
$C_9H_6O_2$	Phenylpropiolic acid (423, 527); EtOH (386, 607, 619)
$C_9H_7ClN_2$	3-Phenyl-5-chloropyrazole (554)
$C_9H_7ClN_2O$	1-Phenyl-3-chloropyrazolone (554)
C_9H_7N	Quinoline (650‡); P (509†); EtOH (143, 262, 263,† 386, 509†); HCl (143, 223, 386); $CHCl_3$, HI (223); Vap. (509†); *cf.* p. 360
C_9H_7N	Isoquinoline: EtOH (386, 606‡); Et_2O (606‡); EtOH + HCl (386); hexane (156,‡ 603,‡ 606‡); *cf.* p. 360
C_9H_7NO	α-Hydroxyquinoline (479‡); EtOH (275)
C_9H_7NO	6-Hydroxyquinoline: EtOH (135)
C_9H_7NO	8-Hydroxyquinoline: EtOH (+NaOH) (+HCl) (158)
C_9H_7NO	β-Indole aldehyde (648)
$C_9H_7NO_2$	β-Indolecarboxylic acid (648)
$C_9H_7NO_2$	Methyl *o*-cyanobenzoate: Et_2O (576)
$C_9H_7NO_2$	Methylisophthalimide: Et_2O (576)
$C_9H_7NO_2$	Methylisatin and ψ form: EtOH (275)
$C_9H_7NO_2$	α-Hydroxy-β-indole aldehyde (648‡)
$C_9H_7NO_4$	*o(m, p)*-Nitrocinnamic acid (527)
C_9H_8ClN	Quinoline hydrochloride: EtOH (263†)
$C_9H_8Cl_2N_2$	3-Phenyl-5-chloropyrazole hydrochloride (554)
$C_9H_8N_2$	1-Phenylpyrazole (554)
$C_9H_8N_2O$	1-Phenyl-3, 5-pyrazolone (554); NaOEt (554)
$C_9H_8N_2O$	1(3)-Phenyl-5-pyrazolone (554)
$C_9H_8N_2O_2$	*N*-Methyl-*p*-nitrobenzyl cyanide: MeOH (405)
$C_9H_8N_4O_8$	2, 3, 5-Trinitroacetylaminoanisole: EtOH (453)
$C_9H_8N_4O_8$	2, 3, 6-Trinitroacetylaminoanisole: EtOH, NaOH (453)
C_9H_8O	Cinnamic aldehyde: EtOH, Vap. (523)
$C_9H_8O_2$	Allocinnamic acid: EtOH (619)
$C_9H_8O_2$	Cinnamic acid: H_2O (35, 182,‡ 613, 614, 659†); EtOH (35, 119, 383, 384, 385, 386, 393, 423, 527, 607, 613, 614, 617, 619); NaOEt, HCl (35); C_6H_6 (494‡); *cf.* p. 360; Na salt (182‡); H_2O (659†)
$C_9H_8O_2$	Atropic acid: EtOH (119)
$C_9H_8O_3$	*o*-Coumaric acid: EtOH (43, 385); (+NaOEt) (43); Na salt: EtOH + NaOEt (43)
$C_9H_8O_3$	*m*-Coumaric acid: EtOH (385)
$C_9H_8O_3$	*p*-Coumaric acid: EtOH (385)
$C_9H_8O_3$	*o(m, p)*-Acetoxybenzaldehyde (636, 637)
C_9H_9N	$\alpha(\beta)$-Methylindole: hexane (171‡)
$C_9H_9NO_2$	*N(O)*-Ethyl-*o*-oxycarbanil (283, 479‡)
$C_9H_9NO_3$	Hippuric acid: H_2O (286, 594,† 659†); *cf.* p. 360; Na salt: H_2O (659†)
$C_9H_9NO_4$	*o*-Carbamylphenoxyacetic acid: EtOH (456)
$C_9H_9NO_4$	Dimethyl quinolinate: Et_2O (578)
$C_9H_9N_3O$	$\alpha(\beta)$-4-Acetyl-3, 4-tolylenediazoimide: EtOH (474)
$C_9H_9N_3O_3$	Acetyl-*p*-benzoquinone semicarbazone (293)
C_9H_{10}	$\alpha(\beta)$-Methylstyrene: EtOH (384)
$C_9H_{10}N_2O$	Pyruvaldehyde phenylhydrazone: EtOH, NaOEt (45)
$C_9H_{10}N_2O_3$	Nitroaceto-*p*-toluidine: EtOH (43)

Formula	Name, solvents and literature
	Ultra-violet and Visible.—(*Continued*)
$C_9H_{10}N_4O_6$	2, 3, 6-Trinitrodimethyl-*p*-toluidine: EtOH (471)
$C_9H_{10}O$	Phenyl ethyl ketone (20)
$C_9H_{10}O_2$	*β*-Phenylpropionic acid: EtOH (20, 37,‡ 386, 423, 607, 619); H_2O (659†); *cf.* p. 360; Na salt: H_2O (659†)
$C_9H_{10}O_2$	Benzyl acetate (20†)
$C_9H_{10}O_2$	Ethyl benzoate (37‡)
$C_9H_{10}O_3$	Tropic acid: EtOH (136); *cf.* p. 360
$C_9H_{10}O_3$	Ethyl *o*-hydroxybenzoate and Na salt: EtOH (385)
$C_9H_{10}O_4$	Veratric acid: EtOH (140, 287)
$C_9H_{11}BrN_2$	Acetone *p*-bromophenylhydrazone: EtOH (40)
$C_9H_{11}IN_2$	Dimethylbenziminazolium iodide: H_2O (631)
$C_9H_{11}N$	Tetrahydroquinoline: EtOH (263†)
$C_9H_{11}NO$	8-Hydroxytetrahydroquinoline: EtOH (+HCl) (158)
$C_9H_{11}NO$	Methylacetanilide: EtOH (43)
$C_9H_{11}NO$	*p*-Dimethylaminobenzaldehyde: EtOH (30, 519); HCl (30); Vap. (519)
$C_9H_{11}NO_2$	Phenylalanine: *v.* p. 360
$C_9H_{11}NO_2$	Dimethylanthranilic acid: EtOH (395)
$C_9H_{11}NO_2$	Methyl methylanthranilate: EtOH (395)
$C_9H_{11}NO_2$	Methyl anilinoacetate (386†)
$C_9H_{11}NO_2$	Nitromesitylene: EtOH (43)
$C_9H_{11}NO_3$	Tyrosine (594†); H_2O (286); *cf.* p. 360
$C_9H_{11}NS$	*N*-Methylthioacetanilide (445)
$C_9H_{11}N_3O_2$	Phenetoleazoformamide: EtOH (293)
$C_9H_{11}N_3O_2$	Acetone *p*-nitrophenylhydrazone: EtOH (40)
$C_9H_{11}N_3O_4$	2, 5-Dinitrodimethyl-*p*-toluidine: EtOH (471)
$C_9H_{11}N_3O_4$	2, 6 (and 3, 5)-Dinitrodimethyl-*p*-toluidine: EtOH (471, 472)
$C_9H_{11}N_3O_4$	3, 5-Dinitro-4(6)-methylamino-*o*-xylene: EtOH (477)
C_9H_{12}	Mesitylene (37‡); Vap. (271)
C_9H_{12}	Propylbenzene (20†, 386†)
$C_9H_{12}ClN$	Tetrahydroquinoline hydrochloride: EtOH (263†)
$C_9H_{12}ClNO_2$	Phenylalanine hydrochloride: EtOH (649‡)
$C_9H_{12}ClNO_3$	Tyrosine hydrochloride: EtOH (649‡)
$C_9H_{12}N_2$	Acetaldehyde phenylmethylhydrazone: EtOH (40)
$C_9H_{12}N_2$	Propionaldehyde phenylhydrazone: EtOH + AcOH (40)
$C_9H_{12}N_2$	Acetone phenylhydrazone: EtOH, AcOH (40)
$C_9H_{12}N_2O$	Dimethylbenziminazolol: EtOH (631)
$C_9H_{12}N_2O_2$	2-Nitrodimethyl-*p*-toluidine: EtOH (471)
$C_9H_{12}N_2O_2$	3-Nitrodimethyl-*p*-toluidine: EtOH (43, 471)
$C_9H_{12}N_2O_4S$	*γ*-Cumenediazonium sulfate: H_2O (247)
$C_9H_{12}O$	Benzyl ethyl ether (37‡); EtOH (20); Vap. (624)
$C_9H_{12}O_2$	Tetramethylpyrone (21†)
$C_9H_{12}O_3$	Phloroglucinol trimethyl ether: EtOH (281)
$C_9H_{13}N$	Mesidine: P, EtOH, Vap. (510)
$C_9H_{13}N$	Dimethyl-*o*-toluidine: EtOH (384, 386)
$C_9H_{13}NO$	*γ*-Ethoxylutidine (14)
$C_9H_{13}NO_2$	Ethyl dimethylpyrrolecarboxylate (363, 364)
$C_9H_{13}NO_3$	Adrenaline (128†)
$C_9H_{14}ClN$	Phenyltrimethylammonium chloride: EtOH (395)
$C_9H_{14}ClN$	Dimethyl-*o*-toluidine hydrochloride: EtOH (384)
$C_9H_{14}IN$	Phenyltrimethylammonium iodide: EtOH (395)
$C_9H_{14}N_2O_2$	Ethyl 1-amino-2, 5-dimethyl-4-pyrrolecarboxylate (362)
$C_9H_{14}O$	Phorone (14, 66,‡ 67,‡ 70,‡ 176, 411); EtOH (404, 406, 410, 573‡); H_2O, hexane, AcOH (573‡); H_2SO_4 (406, 573‡); $CHCl_3$, $ZnCl_2$ (406); Vap. (539†); *cf.* p. 360
$C_9H_{14}O_5$	Diethyl acetonedicarboxylate (58‡, 176); EtOH (+alk.) (23†)
$C_9H_{14}O_5$	Diethyl hydroxymethylenesuccinate: EtOH (22)
$C_9H_{15}BrO_4$	Dipropyl bromomalonate (198)
$C_9H_{15}NO_3$	Ecgonine: *v.* p. 360
$C_9H_{15}N_3O_3$	Triethyl isocyanurate (120); EtOH (280)
$C_9H_{15}N_3O_3$	Triethyl cyanurate (120)
C_9H_{16}	Geraniolene: Vap. (602)
$C_9H_{17}NO_2$	Ethyl piperidoacetate (395†)
$C_9H_{18}N_6$	Triethyl(iso)melamine: EtOH (280)
$C_9H_{18}O$	Hexamethylacetone (294, 545‡); P, H_2O, EtOH, heptane, $CHCl_3$ (546‡)
$C_9H_{19}NO_2$	*d*-*γ*-Nonyl nitrite: P (490†)
$C_9H_{21}N$	Tripropylamine (63‡)
$C_{10}H_6Cl_2$	Dichloronaphthalene (*10 isomers*): hexane, Vap. (372.3)
$C_{10}H_6N_2O_4$	Quinoxalindicarboxylic acid and Fe, Na salts: H_2O (394)
$C_{10}H_6O_2$	*α*-Naphthoquinone (36, 410, 432‡); EtOH (409, 518); Vap. (531); *β*-Naphthoquinone (409); EtOH, Vap. (518)
$C_{10}H_6O_3$	Hydroxymethyleneindandione: H_2O (+HCl) (401); Na salt (401)
$C_{10}H_6O_4$	Phthalyl acetic acid: AcOH, H_2SO_4 (500)
$C_{10}H_7Br$	*α*(*β*)-Bromonaphthalene: EtOH, Vap. (518); *cf.* p. 360
$C_{10}H_7BrN_2O_3$	*p*-Bromophenyloximidoxazolone methyl ether: Et_2O (243)
$C_{10}H_7Cl$	*α*(*β*)-Chloronaphthalene: EtOH, Vap. (518)
$C_{10}H_7ClN_2$	*α*-Naphthalenediazonium chloride: H_2O, dil. acid (89, 247)
$C_{10}H_7NO_2$	*α*(*β*)-Nitronaphthalene: EtOH (43, 518); ligroin, C_6H_6 (43)
$C_{10}H_7NO_2$	Cinchoninic acid: *v.* p. 360
$C_{10}H_7NO_3$	Acetylisatin: EtOH (435‡)
$C_{10}H_8$	Naphthalene (42, 133, 324); EtOH (18,† 261,† 263,† 379, 386,† 431, 518, 599, 606‡); hexane (156,‡ 306,‡ 372,‡ 606‡); Et_2O (606‡); Vap. (304, 305, 372, 518, 599); *cf.* p. 360
$C_{10}H_8N_2$	2-Dipyridyl: EtOH, Vap. (263,† 520)
$C_{10}H_8N_2O_2$	*α*-Nitro-*β*-naphthylamine: EtOH (518)
$C_{10}H_8N_4O_5$	4-Nitro-1, *p*-nitrophenyl-3-methyl-5-pyrazolone (554)
$C_{10}H_8O$	*α*(*β*)-Naphthol: EtOH (360, 432,‡ 518); *cf.* p. 360
$C_{10}H_8O_4$	Benzylidenemalonic acid: H_2O, EtOH (+NaOEt) (35)
$C_{10}H_9BrN_2O$	1, *p*-Bromophenyl-5-methyl-3-pyrazolone (554)
$C_{10}H_9ClN_2$	1-Phenyl-3-methyl-5-chloropyrazole (554)
$C_{10}H_9N$	*α*-Naphthylamine: EtOH (518); *cf.* p. 360
$C_{10}H_9N$	*β*-Naphthylamine: EtOH (478, 518); *cf.* p. 360
$C_{10}H_9NO$	*p*-Methoxyquinoline: *v.* p. 360
$C_{10}H_9NO$	6-Methoxyquinoline: EtOH (135)
$C_{10}H_9NO$	Carbostyril *N*(*O*)-methyl ether (275); EtOH (479‡)

Formula	Name, solvents and literature
	Ultra-violet and Visible.—(*Continued*)
$C_{10}H_9N_3O_2$	Isonitrosophenylmethylpyrazolone: EtOH (+NaOEt) (402)
$C_{10}H_9N_3O_3$	1-*m*-Nitrophenyl-5-methyl-5-pyrazolone (554)
$C_{10}H_{10}$	1, 4-Dihydronaphthalene (42); EtOH (379)
$C_{10}H_{10}Br_2O_2$	Dibromothymoquinone: EtOH (610); Vap. (531)
$C_{10}H_{10}ClN$	Quinoline methochloride: H_2O, EtOH (223)
$C_{10}H_{10}ClN$	$\alpha(\beta)$-Naphthylamine hydrochloride: EtOH (518)
$C_{10}H_{10}ClNO$	6-Methoxyquinoline hydrochloride (135)
$C_{10}H_{10}Cl_2O_2$	Dichlorothymoquinone: EtOH (610); Vap. (531)
$C_{10}H_{10}IN$	Quinoline methiodide: EtOH, $CHCl_3$ (223)
$C_{10}H_{10}IN$	Isoquinoline methiodide: EtOH (631); $CHCl_3$ (223)
$C_{10}H_{10}N_2O$	1-Phenyl-3(5)-methyl-5(3)-pyrazolone (554)
$C_{10}H_{10}O$	Benzylideneacetone: H_2O (534); EtOH (13, 35); H_2SO_4 (13)
$C_{10}H_{10}O_2$	Benzoylacetone: EtOH (23,† 475, 478); alk. (23†); Al salts: EtOH, alk. (23†); V salts: EtOH (475)
$C_{10}H_{10}O_2$	*o*(*m*, *p*)-Diacetylbenzene: EtOH, $CHCl_3$, hexane (642)
$C_{10}H_{10}O_2$	(Iso)Safrole: EtOH (119)
$C_{10}H_{10}O_2$	α-Methylcinnamic acid: EtOH (384, 393)
$C_{10}H_{10}O_2$	β-Methylcinnamic acid: EtOH (384)
$C_{10}H_{10}O_3$	Methyl coumarate: EtOH, NaOEt (385)
$C_{10}H_{10}O_4$	Meconin: EtOH, Et_2O (606‡)
$C_{10}H_{10}O_4$	Dimethyl terephthalate (284)
$C_{10}H_{10}O_5$	Opianic acid: EtOH, Et_2O (603,‡ 605,‡ 606‡)
$C_{10}H_{10}O_6$	Dimethoxyterephthalic acid (236)
$C_{10}H_{10}O_6$	Hemipinic acid: EtOH, Et_2O (606‡)
$C_{10}H_{11}NO$	Benzylideneacetoxime (534)
$C_{10}H_{11}NO$	β-Indoleethyl alcohol (648†)
$C_{10}H_{11}NO_4$	Ethyl *p*-nitrophenylacetate: EtOH (+NaOH) (317)
$C_{10}H_{11}N_3O_4$	Nitrodiacetylphenylenediamine: EtOH (477)
$C_{10}H_{11}N_3O_7$	4(6), 5-Dinitro-3-acetylaminoveratrole: Neutral and alk. sol. (190)
$C_{10}H_{12}$	Dicyclopentadiene: Et_2O, EtOH (618)
$C_{10}H_{12}$	1, 2, 3, 4-Tetrahydronaphthalene (42); EtOH (379); Vap. (518)
$C_{10}H_{12}$	1, 4, 6, 9-Tetrahydronaphthalene (42)
$C_{10}H_{12}N_2O$	Diacetylphenylhydrazone: EtOH, NaOEt (45)
$C_{10}H_{12}N_2O$	Pyruvaldehyde phenylmethylhydrazone (45)
$C_{10}H_{12}N_2O_3$	3-Nitromethylaceto-*p*-toluidide: EtOH (43)
$C_{10}H_{12}O$	Anethole (122, 150†)
$C_{10}H_{12}O$	Cumaldehyde: EtOH, Vap. (523)
$C_{10}H_{12}O$	$\alpha(\beta)$-Ethoxystyrene: EtOH (383)
$C_{10}H_{12}O$	Methylchavicole (150†)
$C_{10}H_{12}O$	*ar*-Tetrahydro-$\alpha(\beta)$-naphthol: EtOH (360)
$C_{10}H_{12}O_2$	Eugenol and isoeugenol (150†); EtOH (119, 533, 628‡); Vap. (533†)
$C_{10}H_{12}O_2$	Ethyl phenylacetate (20,† 37‡)
$C_{10}H_{12}O_2$	Thymoquinone (36); Vap. (531)
$C_{10}H_{12}O_3$	Ethyl phenoxyacetate (20)
$C_{10}H_{13}NO_2$	Methyl dimethylanthranilate: EtOH (395)
$C_{10}H_{13}NO_2$	Ethyl anilinoacetate: EtOH (395)
$C_{10}H_{13}NO_2$	*o*-Benzobetaine: EtOH (395)
$C_{10}H_{13}N_3O_4$	3, 5-Dinitro-4(6)-dimethylamino-*o*-xylene: EtOH (477)
$C_{10}H_{13}N_3O_4$	3, 5-Dinitro-4(6)-ethylamino-*o*-xylene: EtOH (477)
$C_{10}H_{13}N_3O_4$	Diethyl-2(3), 4-dinitroaniline: EtOH (218)
$C_{10}H_{14}$	Cymene: EtOH, Vap. (271)
$C_{10}H_{14}$	*m*-Cymene: EtOH (225)
$C_{10}H_{14}$	*tert.*-Butylbenzene (20,† 37‡)
$C_{10}H_{14}BrClO$	α, α'-Chlorobromocamphor: EtOH (412)
$C_{10}H_{14}Br_2O$	α, $\alpha'(\beta)$-Dibromocamphor: EtOH (412)
$C_{10}H_{14}BrNO_3$	α, α'-Bromonitrocamphor: EtOH (412)
$C_{10}H_{14}BrNO_3$	$\beta(\pi)$-Bromonitrocamphor: EtOH, Et_2O, $C_2H_4Cl_2$ (412); Na salt: EtOH (412)
$C_{10}H_{14}ClNO_3$	α, α'-Chloronitrocamphor: EtOH (412)
$C_{10}H_{14}Cl_2O_2$	Camphoryl chloride, *cis* and *cis-trans:* Et_2O (578)
$C_{10}H_{14}N_2$	Acetone phenylmethylhydrazone: EtOH (40)
$C_{10}H_{14}N_2$	Propionaldehyde phenylmethylhydrazone: EtOH(40)
$C_{10}H_{14}N_2$	Nicotine: P, Vap. (509); EtOH (136, 264, 509)
$C_{10}H_{14}N_4O_3$	Ethoxycaffeine: EtOH (269)
$C_{10}H_{14}O$	Carvacrol: EtOH, Vap.† (533)
$C_{10}H_{14}O$	Carvone (294); Vap. (532)
$C_{10}H_{14}O$	Thymol: H_2O (286); EtOH (385, 533); EtOH + NaOEt (660†); Vap. (533); Na salt (660†)
$C_{10}H_{14}O_2$	Camphorquinone (416†); EtOH (415, 609); C_6H_6 (415); toluene (644‡); Vap. (532)
$C_{10}H_{14}O_3$	Camphoric anhydride: Vap. (532)
$C_{10}H_{14}O_4$	Tetraacetylethane: EtOH (+NaOEt) (21)
$C_{10}H_{15}BrO$	α-Bromocamphor: EtOH (412, 413)
$C_{10}H_{15}BrO$	β-Bromocamphor: EtOH (412)
$C_{10}H_{15}BrO_4S$	*d*-α-Bromocamphor-β-sulfonic acid, NH_4 salt: EtOH (525)
$C_{10}H_{15}BrO_4S$	α-Bromocamphor-π-sulfonic acid, NH_4 salt: EtOH (413)
$C_{10}H_{15}ClO$	α-Chlorocamphor: H_2O, EtOH (412, 413)
$C_{10}H_{15}ClO_4S$	α-Chlorocamphor-β-sulfonic acid, K salt: H_2O, NaOH (413)
$C_{10}H_{15}N$	Diethylaniline: P, EtOH, Vap. (510)
$C_{10}H_{15}NO$	Carvoneoxime: EtOH (532)
$C_{10}H_{15}NO_2$	Ethyl trimethylpyrrolecarboxylate (363, 364)
$C_{10}H_{15}NO_2$	Isonitrosocamphor: EtOH (+alk.) (31)
$C_{10}H_{15}NO_2S$	Camphor-β-sulfonanhydramide: EtOH (413)
$C_{10}H_{15}NO_3$	Nitrocamphor: EtOH, Et_2O, $C_2H_4Cl_2$ (412); Na salt: EtOH (412)
$C_{10}H_{15}N_3O_3$	Ethyl 2, 5-dimethyl-1-ureido-4-pyrrolecarboxylate (362)
$C_{10}H_{16}$	Bornylene: Vap. (602)
$C_{10}H_{16}$	Camphene: Vap. (602)
$C_{10}H_{16}$	Dipentene (225)
$C_{10}H_{16}$	Limonene (120); EtOH (225); Vap. (602)
$C_{10}H_{16}$	$\alpha(\beta)$-Phellandrene: EtOH (225); Vap. (602)
$C_{10}H_{16}$	α-Pinene: EtOH (225); Vap. (602)
$C_{10}H_{16}$	Sylvestrene: EtOH (225); Vap. (602)
$C_{10}H_{16}$	Terpinene (120)
$C_{10}H_{16}$	Terpinolene (120)
$C_{10}H_{16}$	Turpentine (260†)
$C_{10}H_{15}BrNO_3S$	α-Bromocamphor-π-sulfonamide: EtOH (413)
$C_{10}H_{16}ClNO_3S$	α-Chlorocamphorsulfonamide: EtOH (413)
$C_{10}H_{16}N_2O$	$\alpha(\beta)$-Camphorquinonehydrazone (368)
$C_{10}H_{16}N_2O_2$	Methyl γ-diazocamphonanate (349.5)
$C_{10}H_{16}N_2O_2$	Ethyl 1-amino-2, 3, 5-trimethyl-4-pyrrolecarboxylate (362)
$C_{10}H_{16}O$	Camphor (294, 416); EtOH (31, 261,† 270, 412, 415,‡ 525); Et_2O, $C_2H_4Cl_2$ (412); cyclohexane (415‡); Vap. (532)
$C_{10}H_{16}O$	Carvenone (120)

Formula	Name, solvents and literature
	Ultra-violet and Visible.—*(Continued)*
$C_{10}H_{16}O$	Citral (66,‡ 67‡); EtOH (533, 539); Vap. (539); *cf.* p. 360
$C_{10}H_{16}O$	Dihydrocarvone (120)
$C_{10}H_{16}O$	Fenchone (294); Vap. (532)
$C_{10}H_{16}O$	Pulegone (120); EtOH, Vap. (533)
$C_{10}H_{16}O_2$	Buccocamphor (447)
$C_{10}H_{16}O_4$	Camphoric acid: EtOH (261†); Na salt: H_2O (578)
$C_{10}H_{16}O_5$	Diethyl acetylsuccinate: EtOH (+alk.) (23†)
$C_{10}H_{16}O_5$	Diethyl ethoxyfumarate: EtOH (23,† 237); alk. (23†)
$C_{10}H_{16}O_5$	Diethyl dimethyloxalacetate: EtOH (237)
$C_{10}H_{17}N$	Camphorimide: EtOH (532)
$C_{10}H_{17}NO$	Camphoroxime: EtOH (31, 525)
$C_{10}H_{17}NO_2$	Nitrocamphane: EtOH (+NaOH) (412)
$C_{10}H_{17}NO_3S$	Camphor-β-sulfonamide: EtOH (413)
$C_{10}H_{18}O$	*d(l)*-Borneol: EtOH (225)
$C_{10}H_{18}O$	Cineol: EtOH (225)
$C_{10}H_{18}O$	Citronellal: EtOH (533)
$C_{10}H_{18}O$	*l*-Linalool: EtOH (533†)
$C_{10}H_{18}O$	Geraniol: EtOH (533†)
$C_{10}H_{18}O$	Menthone (294); EtOH (533)
$C_{10}H_{18}O_2$	Acetylmethyl hexyl ketone (176, 294)
$C_{10}H_{18}O_3$	Ethyl diethylacetoacetate (68,‡ 255†); EtOH (204,‡ 220, 226, 609); H_2O (204‡); *cf.* p. 360
$C_{10}H_{19}NO$	Menthone oxime: EtOH (533)
$C_{10}H_{20}O$	Menthol: EtOH (533)
$C_{11}H_5Cl_3O_2$	Cyclopentadienechloranil (411)
$C_{11}H_7BrN_2O_4$	*p*-Bromophenylacetyloximidoxazolone: Et_2O (243)
$C_{11}H_7N$	α(β)-Naphthonitrile: *v.* p. 360
$C_{11}H_8O_2$	α(β)-Naphthoic acid: *v.* p. 360
$C_{11}H_8O_3$	β-2-Naphthol-3-carbonic acid, Na salt: EtOH (385)
$C_{11}H_9BrIN$	Iodophenylpyridinium bromide: EtOH (338)
$C_{11}H_9I_2N$	Iodophenylpyridinium iodide: EtOH (338)
$C_{11}H_9N$	Phenylpyridine, salts and derivatives (338)
$C_{11}H_9N$	4-Phenylpyridine: Vap. (520)
$C_{11}H_9NO_2$	Diketo-*o(m, p)*-tolylpyrroline: EtOH (512†)
$C_{11}H_9NO_3$	Quininic acid: *v.* p. 360
$C_{11}H_{10}$	α-Methylnaphthalene (432‡); *cf.* p. 360
$C_{11}H_{10}$	β-Methylnaphthalene (432‡); hexane, Vap. (372‡); *cf.* p. 360
$C_{11}H_{16}IN$	Phenylpyridinium iodide: $CHCl_3$ (338)
$C_{11}H_{16}N_2O_3$	Anisalhydantoin, derivatives: EtOH (93)
$C_{11}H_{10}O$	α(β)-Naphthyl methyl ether: EtOH (360)
$C_{11}H_{10}O_2$	2, 3-Dimethylchromone: EtOH (+alk.) (292‡)
$C_{11}H_{10}O_2$	Ethyl phenylpropiolate (423)
$C_{11}H_{10}O_2$	Methyloxindone (230); Na, Rb salts: EtOH (230)
$C_{11}H_{10}O_2$	Cinnamylideneacetic acid (423)
$C_{11}H_{10}O_4$	Ethyl coumaranonecarboxylate and Na salt: EtOH (456)
$C_{11}H_{11}ClN_2$	1, *o*-Tolyl-3(5)-methyl-5(3)-chloropyrazole (554)
$C_{11}H_{11}NO$	8-Ethoxyquinoline: EtOH (+HCl) (158)
$C_{11}H_{11}NO_2$	β-Indolepropionic acid (648)
$C_{11}H_{11}NO_3$	ω-Aminoethylpiperonylcarboxylic anhydride: EtOH (140, 287)
$C_{11}H_{11}NO_3$	Ketohydrastinine: EtOH (140, 287)
$C_{11}H_{11}NO_4$	Ethyl *o(m, p)*-nitrocinnamate: EtOH (43)
$C_{11}H_{12}N_2O$	1-Phenyl-2, 3-dimethyl-5-pyrazolone (554)
$C_{11}H_{12}N_2O$	1, *o*-Tolyl-3(5)-methyl-5(3)-pyrazolone (554)
$C_{11}H_{12}N_2O$	1, *p*-Tolyl-3-methyl-5-pyrazolone (554)
$C_{11}H_{12}N_2O_2$	Tryptophane: EtOH (648,‡ 649); *cf.* p. 360
$C_{11}H_{12}N_4O_6$	2, 4, 6-Trinitrophenylpiperidine: EtOH (477)
$C_{11}H_{12}O_2$	α, β-Dimethylcinnamic acid: EtOH (393)
$C_{11}H_{12}O_2$	Ethyl cinnamate (37‡); EtOH (35)
$C_{11}H_{12}O_2$	Anisalacetone: EtOH, H_2SO_4 (13)
$C_{11}H_{12}O_3$	Ethyl *o(m)*-coumarate: EtOH (+NaOEt) (385)
$C_{11}H_{12}O_3$	β-Ethoxycinnamic acid: EtOH (383)
$C_{11}H_{12}O_3$	Ethyl benzoylacetate: EtOH (23); (+NaOEt) (23, 385); Al salts: EtOH (+NaOEt) (23); Na salt: EtOH (383)
$C_{11}H_{12}O_4$	Diacetyldimethylpyrone; EtOH (+NaOEt) (21)
$C_{11}H_{12}O_6$	Diethyl chelidonate (21)
$C_{11}H_{13}Br_2N_3O_2$	Dibromo-4-hydroxy-2-methyl-5-isopropyl-benzeneazoformamide: EtOH (+NaOH) (293)
$C_{11}H_{13}N$	Dimethyldihydroisoquinoline: EtOH (631)
$C_{11}H_{13}N$	Corydaldine: H_2O (140, 287)
$C_{11}H_{13}NO_2$	Hydrohydrastinine: Et_2O (145); hexane (606‡)
$C_{11}H_{13}NO_3$	Hydrastinine: hexane (606‡); EtOH (140, 287, 606‡); H_2O, Et_2O (145, 606‡)
$C_{11}H_{13}NO_4$	Ethyl *o*-carbamylphenoxyacetate: EtOH (456)
$C_{11}H_{13}N_3O_4$	2, 4-Dinitrophenylpiperidine: EtOH (477)
$C_{11}H_{14}BrN_3O_2$	3-Bromo-4-hydroxy-2-methyl-5-isopropyl-benzeneazoformamide: EtOH (+NaOH) (293)
$C_{11}H_{14}Br_2O_2$	Cyclohexanespiro-4, 4-dibromocyclohexan-3, 5-dione: EtOH (199)
$C_{11}H_{14}ClNO_3$	Hydrastinine hydrochloride: H_2O (145)
$C_{11}H_{14}ClN_3O$	4-Aminoantipyrine hydrochloride: EtOH (478)
$C_{11}H_{14}Cl_2O_2$	Cyclohexanespiro-4, 4-dichlorocyclohexan-3, 5-dione: EtOH (199)
$C_{11}H_{14}N_2O$	Cytisine: *v.* p. 360
$C_{11}H_{14}O$	Formylcamphor anhydride (416)
$C_{11}H_{14}O$	*ar*-Tetrahydro-α(β)-naphthyl methyl ether: EtOH (360)
$C_{11}H_{14}O_2$	Methylisoeugenol (150†)
$C_{11}H_{14}O_3$	Ethyl *o*-hydrocoumarate and Na salt: EtOH (+NaOEt) (385)
$C_{11}H_{14}O_7$	Diethyl xanthochelidonate: H_2O, EtOH, $CHCl_3$ (21)
$C_{11}H_{15}BrO_2$	Cyclohexanespiro-4-bromocyclohexan-3, 5-dione: EtOH (199)
$C_{11}H_{15}BrO_2$	Bromoformylcamphor (416)
$C_{11}H_{15}N$	4-Phenylpiperidine: EtOH (+acid), Vap. (520)
$C_{11}H_{15}NO$	*p*-Toluidineacetaldehyde condensation compounds (507)
$C_{11}H_{15}N_3O_2$	4-Hydoxy-2-methyl-5-isopropylbenzeneazoformamide: EtOH + NaOH (293)
$C_{11}H_{16}BrNO_2$	Bromocamphorcarboxylic amide (414)
$C_{11}H_{16}Br_2O$	α, ω-Dibromomethylcamphor: EtOH (412)
$C_{11}H_{16}N_2$	Diethyl ketone phenylhydrazone: EtOH + AcOH (40)
$C_{11}H_{16}O$	Methylenecamphor (416)
$C_{11}H_{16}O_2$	Formylcamphor: EtOH, NaOEt (416)
$C_{11}H_{16}O_2$	Hydroxymethylenecamphor (560); EtOH (+alk.) (23,† 416)
$C_{11}H_{16}O_2$	Cyclohexanespirocyclohexan-3, 5-dione: EtOH (+NaOEt) (199)
$C_{11}H_{16}O_3$	Camphorcarboxylic acid and Na salt (414)
$C_{11}H_{17}BrO$	α(β, ω)-Bromomethylcamphor: EtOH (412)
$C_{11}H_{17}NO$	Aminomethylenecamphor: EtOH (+HCl) (416)

Formula	Name, solvents and literature
	Ultra-violet and Visible.—(*Continued*)
$C_{11}H_{17}NO_2$	Isonitrosocamphor-*O*-methyl ether: EtOH (31)
$C_{11}H_{17}NO_2$	Camphorcarboxylic amide (414)
$C_{11}H_{17}N_3O_2$	$\alpha(\beta)$-Camphorquinonesemicarbazone (368)
$C_{11}H_{17}N_3O_3$	Ethyl 2, 3, 5-trimethyl-1-ureido-4-pyrrole-carboxylate (362)
$C_{11}H_{18}O$	Methylcamphor: EtOH (412)
$C_{11}H_{19}NO_3S$	α-Methylcamphorsulfonamide: EtOH (413)
$C_{11}H_{19}N_3O$	Fenchone semicarbazone (245)
$C_{11}H_{20}O_4$	Diethyl diethylmalonate: EtOH (82, 198); (+NaOEt) (82)
$C_{11}H_{22}O$	Methyl nonyl ketone (176, 294, 545‡); EtOH (609)
$C_{12}H_6Br_4N_2O_2$	$\alpha(\beta)$-Tetrabromo-*p*-azophenol: EtOH (549)
$C_{12}H_6N_8O_{12}$	Hexanitrohydrazobenzene: MeOH, $CHCl_3$, HCl, NaOEt (248)
$C_{12}H_6O_2$	Diphenoquinone: EtOH (409)
$C_{12}H_6O_2$	Acenaphthenequinone: EtOH (36)
$C_{12}H_7NO_3$	Resorufin: EtOH (482‡)
$C_{12}H_8$	Acenaphthylene: EtOH (42)
$C_{12}H_8Br_2N_2O$	Benzeneazo-2, 6-dibromophenol (250)
$C_{12}H_8N_2$	Phenazine: EtOH (234)
$C_{12}H_8N_2O_2$	Benzoquinoneazine (44)
$C_{12}H_8N_4O_6$	Phenylpicramide: EtOH (218, 248); (+NaOEt) (248)
$C_{12}H_8O$	Diphenylene oxide: EtOH (138)
$C_{12}H_8OS_2$	Thianthrene sulfoxide: EtOH (189)
$C_{12}H_8S_2$	Thianthrene: EtOH (189)
$C_{12}H_9Br$	4-Bromoacenaphthene: EtOH (518)
$C_{12}H_9Cl$	4-Chloroacenaphthene: EtOH (518)
$C_{12}H_9ClN_4$	Benzeneazobenzenediazonium chloride: EtOH (319)
$C_{12}H_9Cl_2NS$	2, 5-Dichlorobenzenesulfuranilide: $CHCl_3$ (174.2‡)
$C_{12}H_9I$	4-Iodoacenaphthene: EtOH (518)
$C_{12}H_9IN_2$	Iodoazobenzene: EtOH, HCl (319)
$C_{12}H_9N$	Carbazole: *v.* p. 360
$C_{12}H_9N_3O_3$	*o*(*m*, *p*)-Nitrobenzeneazophenol: EtOH (+NaOEt) (44)
$C_{12}H_9N_3O_3$	*p*-Nitrobenzeneazophenol: EtOH (44, 496, 592); K salt: EtOH (592); Na salt (496); EtOH (592)
$C_{12}H_9N_3O_4$	*p*-Dinitrodiphenylamine, Na salt: EtOH (244)
$C_{12}H_9N_3O_4$	Phenyl-2, 4-dinitroaniline: EtOH (218)
$C_{12}H_9N_5O_4$	*m*, *p*-Dinitrodiazoaminobenzene and derivatives: EtOH (593)
$C_{12}H_9N_5O_4$	*p*, *p*′-Dinitrodiazoaminobenzene, Na salt: EtOH (244)
$C_{12}H_{10}$	Diphenyl (37,‡ 42); EtOH (431‡); Vap. (521); *cf.* p. 360
$C_{12}H_{10}$	Acenaphthene (42); EtOH, Vap. (518)
$C_{12}H_{10}N_2$	Azobenzene (196,‡ 229); EtOH (29, 40, 83.3, 117, 213,† 216, 247, 422,‡ 486,† 521, 537); acid (29, 83.3, 216, 633); $CHCl_3$ (216, 537); MeOH (216); ligroin (83.3); Vap. (521); *cf.* p. 360
$C_{12}H_{10}N_2O$	Azoxybenzene: EtOH (521, 526,† 434‡); Vap. (521)
$C_{12}H_{10}N_2O$	Benzeneazophenol (196‡); EtOH (183, 250, 550, 592, 633); H_2SO_4 (216); HCl, NaOEt (633); K salt (592); Li salt: Et_2O (250); Rb salt: EtOH, C_5H_5N (250)
$C_{12}H_{10}N_2O_2$	Azophenol: EtOH (219, 549, 634); Et_2O (219); (+NaOEt) (634)

Formula	Name, solvents and literature
$C_{12}H_{10}N_4O_2$	*p*-Nitroazoaminobenzene, Na salt: EtOH (244)
$C_{12}H_{10}N_4O_4$	3, 3′(5)-Dinitrobenzidine: EtOH, HCl, NaOH (90)
$C_{12}H_{10}O$	Diphenyl ether: EtOH (161†); $CHCl_3$ (537); Vap. (161,† 521)
$C_{12}H_{10}O$	*o*-Hydroxydiphenyl: EtOH (+NaOEt) (385)
$C_{12}H_{10}OS$	Diphenyl sulfoxide: EtOH (189)
$C_{12}H_{10}O_2$	Cinnamylideneacrylic acid: EtOH (+NaOEt) (35)
$C_{12}H_{10}O_2$	Diphenol: EtOH (409)
$C_{12}H_{10}O_2S$	Diphenyl sulfone: EtOH (189)
$C_{12}H_{10}O_2S_2$	Diphenyl disulfoxide: EtOH (189)
$C_{12}H_{10}O_3$	Acetyloxindone, Ca, Cs, Li salts: EtOH (230)
$C_{12}H_{10}O_4$	Cinnamylidenemalonic acid: EtOH (35, 614); H_2O, HCl, NaOEt (35)
$C_{12}H_{10}O_4$	Ethyl oxindonecarboxylate, Ag,† Ba,† Ca, Cs, K, Li, Na,† Rb,† Sr,† Tl† salts: EtOH (230)
$C_{12}H_{10}O_4S_2$	Diphenyl disulfone: EtOH (189)
$C_{12}H_{10}O_4$	Piperic acid: EtOH (136)
$C_{12}H_{10}O_4$	Quinhydrone: EtOH (288, 405); Vap. (288)
$C_{12}H_{10}S$	Diphenyl sulfide (189); EtOH, Vap. (161)
$C_{12}H_{10}S_2$	Diphenyl disulfide: EtOH (161, 189)
$C_{12}H_{11}N$	Diphenylamine: EtOH (13, 410, 537); Vap. (521); *cf.* p. 360
$C_{12}H_{11}NO_4$	6, 7-Dimethoxyisoquinoline-1-carboxylic acid (137)
$C_{12}H_{11}N_3$	*p*-Aminoazobenzene: EtOH (29, 183, 486,† 521, 634); acid (29, 319); Vap. (521)
$C_{12}H_{11}N_3$	Diazoaminobenzene: EtOH (247, 521); Vap. (521)
$C_{12}H_{11}N_3O$	*p*-Aminobenzeneazophenol: EtOH, HCl (318)
$C_{12}H_{11}N_3O_4S$	Diphenylamine-*p*- diazonium sulfate: H_2O, acid (247)
$C_{12}H_{12}$	Dimethylnaphthalene: hexane, Vap. (372‡); *cf.* p. 360
$C_{12}H_{12}Cl_2O_6$	Diethyl *p*-dichlorodihydroxyterephthalate: MeOH, $C_5H_{11}OH$, $CHCl_3$ (224, 236); EtOH, Et_2O (236)
$C_{12}H_{12}N_2$	Benzidine: EtOH (90, 521); Vap. (521)
$C_{12}H_{12}N_2$	Hydrazobenzene: $CHCl_3$ (537)
$C_{12}H_{12}N_2O_3$	Luminal: *v.* p. 360
$C_{12}H_{12}O$	Cinnamylideneacetone: EtOH (+NaOEt) (35)
$C_{12}H_{12}O_3$	6(7, 8)-Methoxy-2, 3-dimethylchromone: EtOH (+alk.) (292‡)
$C_{12}H_{13}ClN_2$	1, *o*-Tolyl-3, 4-dimethyl-5-chloropyrazole (554)
$C_{12}H_{13}N$	$\alpha(\beta)$-Dimethylnaphthylamine: *v.* p. 360
$C_{12}H_{14}Br_2O_6$	Diethyl dihydroxyterephthalate dibromide: EtOH (235)
$C_{12}H_{14}Cl_2O_6$	Diethyl β-dichlorosuccinylsuccinate: EtOH (235)
$C_{12}H_{14}N_2O$	1, *o*-Tolyl-3, 4-dimethyl-5-pyrazolone (554)
$C_{12}H_{14}O_4$	Apiole: EtOH (119)
$C_{12}H_{14}O_4$	Isoapiole: EtOH (119)
$C_{12}H_{14}O_4$	Diethyl phthalate: Et_2O (577)
$C_{12}H_{14}O_6$	Diethyl dihydroxyterephthalate: EtOH (235); MeOH, $CHCl_3$ (236)
$C_{12}H_{14}INO(?)$	Anisylpyridinium iodide: $CHCl_3$ (338)
$C_{12}H_{15}NO$	Benzoylpiperidine: EtOH, Vap. (520)
$C_{12}H_{15}NO_3$	Hydrocotarnine (144†); HCl (223); hexane (603,‡ 605‡); var. solvents (606‡)
$C_{12}H_{15}NO_4$	Cotarnine: EtOH (144,† 264, 606‡); H_2O, Et_2O, hexane (144,† 606‡); $CHCl_3$, NaOH (144†)

Formula	Name, solvents and literature
	Ultra-violet and Visible.—(*Continued*)
$C_{12}H_{16}Br_4O_6$	Diethyl tetrabromosuccinylsuccinate: EtOH (235)
$C_{12}H_{16}ClNO_2$	6, 7-Dimethoxy-3, 4-dihydroisoquinoline methochloride: H_2O (631)
$C_{12}H_{16}ClNO_4$	Cotarnine hydrochloride: EtOH (144,† 223); H_2O (223, 606‡); $CHCl_3$, HCl (223)
$C_{12}H_{16}INO_4$	Cotarnine hydroiodide: EtOH (223)
$C_{12}H_{16}O$	Methyl duryl ketone (176)
$C_{12}H_{16}O_6$	Diethyl succinylsuccinate: Et_2O, AcOH + H_2SO_4, MeOH, EtOH (235)
$C_{12}H_{17}NO_2$	6, 7-Dimethoxy-2-methyltetrahydroisoquinoline: $CHCl_3$, Et_2O (631)
$C_{12}H_{17}NO_4$	Diethyl 2, 5-dimethyl-3, 4-pyrroledicarboxylate (362)
$C_{12}H_{18}$	Hexamethylbenzene: EtOH (386, 403, 524†)
$C_{12}H_{18}N_2$	Diethyl ketone phenylmethylhydrazone: EtOH (40)
$C_{12}H_{18}N_2O_5$	α-Glucose phenylhydrazone (45)
$C_{12}H_{18}O_2$	Acetylcamphor: EtOH (+NaOEt) (416)
$C_{12}H_{18}O_3$	Camphorylacetic acid (559)
$C_{12}H_{18}O_3$	Methyl camphocarboxylate: NaOEt (414)
$C_{12}H_{18}O_6$	Diethyl diacetylsuccinate: EtOH (+alk.) (23†)
$C_{12}H_{20}OS_2$	Methyl bornylxanthate: EtOH (97)
$C_{12}H_{20}OS_2$	Methyl fenchylxanthate (97)
$C_{12}H_{20}O_2$	Tetraethyldiketocyclobutane: hexane (370,‡ 371‡)
$C_{12}H_{20}O_5$	Diethyl diethyloxalacetate: EtOH (237)
$C_{12}H_{22}$	Dimethyldecadiene (560)
$C_{12}H_{22}O_{11}$	Cane sugar (265,† 532, 594)
$C_{12}H_{22}O_{11}$	Lactose: H_2O (532)
$C_{12}H_{24}O_2$	Lauric acid: EtOH (252)
$C_{12}H_{26}O$	*d*(*l*)-Laurinol: EtOH (225)
$C_{12}H_{28}IN$	Tetrapropylammonium iodide: $CHCl_3$, EtOH (242)
$C_{13}H_8N_2O_4$	Dinitrofluorene: EtOH (43)
$C_{13}H_8O$	Fluoreneketone: EtOH (615)
$C_{13}H_9ClN_2$	2-Fluorenediazonium chloride: H_2O, acid (247)
$C_{13}H_9NO$	Fluorenone oxime: EtOH (+NaOEt) (400)
$C_{13}H_9NO_2$	Nitrofluorene: EtOH (43)
$C_{13}H_{10}$	Fluorene (42); EtOH, ligroin (71); *cf.* p. 360
$C_{13}H_{10}N_2$	Diphenyldiazomethane: *v.* p. 360
$C_{13}H_{10}N_2O_2$	Benzylidene-*m*(*p*)-nitroaniline: EtOH (43)
$C_{13}H_{10}N_2O_2$	*o*(*m*, *p*)-Nitrobenzylideneaniline: EtOH (43)
$C_{13}H_{10}N_4O_6$	α(β)-Methylphenylpicramide: EtOH (217)
$C_{13}H_{10}N_4O_6$	*o*, *p*-Tolylpicramide: EtOH, NaOEt (248)
$C_{13}H_{10}O$	Benzophenone (37, 410, 571,‡ 572‡); EtOH (5.5, 71, 201, 253, 406, 537, 540, 615); $CHCl_3$ + $ZnCl_2$ (406); Vap. (540); *cf.* p. 360
$C_{13}H_{10}OS_2$	Diphenyl dithiocarbonate: EtOH (536)
$C_{13}H_{10}O_2$	Phenyl benzoate: EtOH (384)
$C_{13}H_{10}O_2S$	Phenyl thiocarbonate (536)
$C_{13}H_{10}O_3$	Phenyl carbonate: EtOH (536)
$C_{13}H_{10}O_3$	Phenyl salicylate: EtOH (384, 386)
$C_{13}H_{10}S_3$	Phenyl trithiocarbonate: EtOH (536)
$C_{13}H_{11}ClN_2O_2S$	4-Chloro-2-nitrophenylsulfurmethylanilide: $CHCl_3$ (174.2‡)
$C_{13}H_{11}ClN_2O_4$	Phenazonium methylperchlorate: EtOH (234)
$C_{13}H_{11}IN_2$	Phenazonium methiodide: EtOH (234)
$C_{13}H_{11}N$	Benzylideneaniline (337); EtOH (43)
$C_{13}H_{11}NO$	Benzanilide: EtOH (119)
$C_{13}H_{11}NO$	Benzophenoneoxime: EtOH (119, 400); (+NaOEt) (400)
$C_{13}H_{11}N_3O_2$	*o*(*m*)-Nitrobenzaldehyde phenylhydrazone: EtOH (40)
$C_{13}H_{11}N_3O_2$	*p*-Nitrobenzaldehyde phenylhydrazone: EtOH (314)
$C_{13}H_{11}N_3O_2$	Benzaldehyde *p*-nitrophenylhydrazone: EtOH (+NaOH) (314)
$C_{13}H_{11}N_3O_4$	*o*-Tolyl-2, 4-dinitroaniline (217); EtOH, $CHCl_3$ (218)
$C_{13}H_{11}N_3O_4$	*m*-Tolyl-2, 4-dinitroaniline: EtOH, $CHCl_3$ (218)
$C_{13}H_{11}N_3O_4$	*p*-Tolyl-2, 4-dinitroaniline: EtOH (218)
$C_{13}H_{11}N_3O_4$	2, 4-Dinitrobenzylaniline: EtOH (477)
$C_{13}H_{11}NS$	Thiobenzanilide (445)
$C_{13}H_{12}$	Diphenylmethane (37‡); EtOH (13, 443,† 483.3, 537); Vap. (521); *cf.* p. 360
$C_{13}H_{12}IN$	Benzylideneaniline hydroiodide (337); EtOH (43)
$C_{13}H_{12}N_2$	Benzaldehyde phenylhydrazone: EtOH (40, 620); (+AcOH) (620)
$C_{13}H_{12}N_2O$	Benzeneazoanisole (196‡)
$C_{13}H_{12}N_2O$	Benzeneazo-*m*(*p*)-cresol: EtOH, HCl, NaOEt (633)
$C_{13}H_{12}N_2O$	*s*-Benzoylphenylhydrazine: EtOH (457)
$C_{13}H_{12}N_2O$	Benzeneazophenyl methyl ether (196‡)
$C_{13}H_{12}N_2O$	1, 1′(2)-Diphenylurea: EtOH (522)
$C_{13}H_{12}N_2O_2$	*p*-Methoxybenzeneazophenol: EtOH (634)
$C_{13}H_{12}N_2S$	*s*-Diphenylthiocarbamide: EtOH (522)
$C_{13}H_{12}N_2S$	Benzeneazothioanisole (160)
$C_{13}H_{12}O$	Phenyl benzyl ether: $CHCl_3$ (537); Vap. (521, 537)
$C_{13}H_{12}O$	Diphenylcarbinol: EtOH (483.3)
$C_{13}H_{12}O_3$	Ethyl β-2-naphthol-3-carbonate: EtOH (385)
$C_{13}H_{12}O_5$	Ethyl coumaranonecarboxylate acetate: EtOH (456)
$C_{13}H_{13}N$	Benzylaniline (537)
$C_{13}H_{13}N_3$	*o*-Toluidineazobenzene: EtOH, HCl (233)
$C_{13}H_{13}N_3O_3S$	*o*-Toluidineazobenzenesulfonic acid: EtOH (233†)
$C_{13}H_{13}N_3O_{10}$	Ethyl trinitrophenylmalonate: $CHCl_3$ (249); H_2O (244)
$C_{13}H_{14}N_2O_3$	Cyanohydrocotarnine (144)
$C_{13}H_{14}N_2O_8$	Ethyl dinitrophenylmalonate (249); K salt: EtOH (244, 249)
$C_{13}H_{16}O_3$	Ethyl β-ethoxycinnamate: EtOH (385)
$C_{13}H_{17}NO_3$	Ethyl 3-hydroxy-1, 1-dimethylcyclohexenylidene-5-cyanoacetate: EtOH, NaOEt (112)
$C_{13}H_{17}N_3O_4$	3, 5-Dinitro-4(6)-piperidino-*o*-xylene: EtOH (477)
$C_{13}H_{18}O_2$	Camphorylideneacetone (559)
$C_{13}H_{18}O_3$	Acetoxymethylenecamphor (416)
$C_{13}H_{19}NO_4$	Diethyl 1, 2, 5-trimethyl-3, 4-pyrroledicarboxylate (362)
$C_{13}H_{20}N_2O_5$	Glucose phenylmethylhydrazone (45)
$C_{13}H_{20}O$	Ionone (176, 410)
$C_{13}H_{20}O_2$	Ethoxymethylenecamphor (416)
$C_{13}H_{20}O_2$	Propionylcamphor: EtOH (+NaOEt) (416)
$C_{13}H_{20}O_3$	Methyl methylcamphorcarboxylate (414)
$C_{13}H_{20}O_3$	Ethyl camphorcarboxylate: NaOEt (414)
$C_{13}H_{22}$	Dimethylundecatriene (560)
$C_{13}H_{22}O_3$	Menthyl pyruvate: C_6H_6 (559)
$C_{14}H_8O_2$	Anthraquinone (36, 432,‡ 464); EtOH (409); Vap. (531)
$C_{14}H_8O_2$	Phenanthraquinone (36, 406, 432‡)
$C_{14}H_8O_3$	9-Ketofluorene-4-carboxylic acid: EtOH (616)
$C_{14}H_9NO_2$	Phthalanil: EtOH, H_2SO_4 (500)
$C_{14}H_9NO_3$	Nitroanthrone: EtOH, $CHCl_3$ (246)

Formula	Name, solvents and literature
	Ultra-violet and Visible.—(*Continued*)
$C_{14}H_{10}$	Anthracene (42, 191‡,†); EtOH (213,† 261, 335,† 426,† 431,‡ 483.3); $(CH_3)_2CO$, $CHCl_3$, ligroin, xylene, isoBuOH, Et_2O, amyl alc. (426)
$C_{14}H_{10}$	Phenanthrene (42, 195‡); EtOH (261, 431‡); hexane (606‡)
$C_{14}H_{10}$	Tolane (423); EtOH (619)
$C_{14}H_{10}O$	Diphenylketene: hexane (370,‡ 371‡)
$C_{14}H_{10}O_2$	Indonecyclomethylacetoethylene (513)
$C_{14}H_{10}O_2$	Benzil (36); EtOH (253); *cf.* p. 360
$C_{14}H_{10}O_2S_2$	Diphenyl dithiooxalate: EtOH (536†)
$C_{14}H_{10}O_3$	*o*-Benzoylbenzoic acid: EtOH (253); Na salt: NaOH (253)
$C_{14}H_{10}O_3$	Oxyphenylphthalide, and neutral alkali salts (462, 463)
$C_{14}H_{10}O_4$	Diphenyl oxalate: EtOH (536)
$C_{14}H_{11}NO_2$	*anti*(*syn*)-Benziloxime: EtOH (217); Na salts: EtOH + NaOH (217)
$C_{14}H_{11}NO_2$	*p*-Nitrostilbene: EtOH (315)
$C_{14}H_{11}NO_3$	*p*-Nitro-*p'*-hydroxystilbene: EtOH (+NaOH) (315)
$C_{14}H_{11}O_5$	2, 4-Dihydroxy-*o*-benzoylbenzoic acid (484.2)
$C_{14}H_{12}$	Dihydroanthracene (42)
$C_{14}H_{12}$	Diphenylethylene: hexane (370,‡ 371‡); *cf.* p. 360
$C_{14}H_{12}$	Stilbene: EtOH (42, 117, 247, 315, 384, 385, 393, 423, 619); $CHCl_3$ (393); *cf.* p. 360
$C_{14}H_{12}IN$	Phenanthridine methiodide (629)
$C_{14}H_{12}IN$	Acridine methiodide: EtOH, NaOH (629)
$C_{14}H_{12}N_2O$	Phenylglyoxal phenylhydrazone (45)
$C_{14}H_{12}N_2O_2$	*p*-Acetylbenzeneazophenol: EtOH (+NaOH) (316)
$C_{14}H_{12}N_2O_2$	Benzeneazophenyl acetate (196‡)
$C_{14}H_{12}N_2O_2$	Piperonal phenylhydrazone: EtOH (+AcOH) (620)
$C_{14}H_{12}N_2O_4$	*dl-m*-Azophenolmandelic acid: EtOH, NaOH (83.5)
$C_{14}H_{12}N_4O_6$	Methyl-*o*(*p*)-tolylpicramide: EtOH (218)
$C_{14}H_{12}O$	Phenyl benzyl ketone: EtOH, Vap. (537)
$C_{14}H_{12}O$	Desoxybenzoin: $CHCl_3$ (392)
$C_{14}H_{12}O$	*p*-Hydroxystilbene: EtOH (+NaOH) (315, 385)
$C_{14}H_{12}O_2$	Benzoin: *v.* p. 360
$C_{14}H_{12}O_3$	3-Acetyl-1-phenyl-4-methyl-1, 3-cyclobutadiene-2-carboxylic acid: EtOH (513)
$C_{14}H_{12}O_3$	1, 2-Diketo-5-acetyl-3-phenyl-4-methyl-Δ^3-cyclopentene, and Na salt: EtOH (513)
$C_{14}H_{12}O_3$	4-Keto-3-acetyl-5-benzylidene-2-methylhydrofuran (513)
$C_{14}H_{13}NO_3$	1, 2-Diketo-5-acetyl-3-phenyl-4-methyl-Δ^3-cyclopenteneoxime: EtOH (513)
$C_{14}H_{13}NS$	*N*(*S*)-Methylthiobenzanilide (445)
$C_{14}H_{13}N_3O$	Acetylaminoazobenzene: EtOH (634)
$C_{14}H_{13}N_3O_2$	Acetophenone *p*-nitrophenylhydrazone: EtOH + NaOH (314)
$C_{14}H_{13}N_3O_2$	*o*(*m*, *p*)-Nitrobenzaldehyde phenylmethylhydrazone: EtOH (40)
$C_{14}H_{13}N_3O_3$	*o*(*m*, *p*)-Nitrobenzeneazophenetole (44†)
$C_{14}H_{13}N_3O_4$	3, 5-Dinitro-4(6)-anilino-*o*-xylene: EtOH (477)
$C_{14}H_{13}N_5O_4$	Ethyl-*m*, *p*-dinitroazoaminobenzene: EtOH (593)
$C_{14}H_{13}N_5O_4$	*m*(*p*)-Nitrobenzeneazoethylamino-*p*-nitrobenzene: EtOH (593)
$C_{14}H_{14}$	Dibenzyl (37,‡ 42, 423); EtOH (117, 384, 393, 619); *cf.* p. 360

Formula	Name, solvents and literature
$C_{14}H_{14}N_2$	Acetophenone phenylhydrazone: EtOH + AcOH (40)
$C_{14}H_{14}N_2$	Benzaldehyde phenylmethylhydrazone: EtOH (40)
$C_{14}H_{14}N_2O$	Anisaldehyde phenylhydrazone: EtOH + AcOH (620)
$C_{14}H_{14}N_2O$	Benzeneazo-*m*(*p*)-cresetole: EtOH, HCl (633)
$C_{14}H_{14}N_2O$	Benzeneazophenetole (196,‡ 250‡); EtOH (293, 633); HCl (633)
$C_{14}H_{14}N_2O$	Benzoylcarbinol phenylhydrazone (45)
$C_{14}H_{14}N_2O$	*p*-Hydroxybenzaldehyde phenylmethylhydrazone: EtOH, NaOEt (634)
$C_{14}H_{14}N_2O$	Salicylaldehyde phenylmethylhydrazone: EtOH, NaOEt(634)
$C_{14}H_{14}N_2O$	*p*-Tolueneazo-*p*-cresol: EtOH, HCl, NaOEt (633)
$C_{14}H_{14}N_2O_3$	Azoxyanisole (526, 548)
$C_{14}H_{14}N_4$	Glyoxal phenylosazone (45)
$C_{14}H_{14}N_4O_2$	*m*(*p*)-Nitrobenzeneazodimethylaniline (44)
$C_{14}H_{14}N_4O_4$	*m*(*o*)-Dinitrotolidine (477)
$C_{14}H_{14}OS$	Dibenzyl sulfoxide: EtOH (189)
$C_{14}H_{14}O_2S$	Dibenzyl sulfone: EtOH (189)
$C_{14}H_{14}O_4$	Dimethyl cinnamylidenemalonate: H_2O, EtOH (35)
$C_{14}H_{14}S$	Dibenzyl sulfide: EtOH (189, 536†)
$C_{14}H_{15}N$	Dibenzylamine: EtOH (537)
$C_{14}H_{15}NO_2$	Diketo-*p*-cumylpyrroline: EtOH (512†)
$C_{14}H_{15}N_3$	*p*-Dimethylaminoazobenzene: EtOH (29, 216, 228, 229, 634); acid (29, 216, 229, 233); alk. (229, 233)
$C_{14}H_{15}N_3O$	*p*-Dimethylaminobenzeneazophenol: EtOH, HCl (318)
$C_{14}H_{15}N_3O_3S$	Dimethylaminoazobenzenesulfonic acid: H_2SO_4 (229); Na salt: H_2O (229)
$C_{14}H_{16}$	Tetramethylnaphthalene (324)
$C_{14}H_{16}ClN_3$	Dimethylaminoazobenzene hydrochloride: EtOH + HCl (216)
$C_{14}H_{16}Cl_2O_6$	Diethyl *p*-dichlorodimethoxyterephthalate: (236)
$C_{14}H_{16}N_2O_2$	Phenylazodimethyldihydroresorcinol: EtOH (+C_5H_5N), (+NaOEt) (401)
$C_{14}H_{16}N_4$	*p*-Aminobenzeneazodimethylaniline: EtOH + HCl (229)
$C_{14}H_{16}N_4$	Dimethylaminobenzeneazoaniline: EtOH + HCl (229)
$C_{14}H_{16}O$	5-Acetyl-3-phenyl-4-methyl-Δ^3-cyclopentene: C_6H_6 (513)
$C_{14}H_{18}O_6$	Diethyl dimethoxyterephthalate (236)
$C_{14}H_{19}NO_4$	Diethyl collidinedicarboxylate: EtOH (386)
$C_{14}H_{20}O_2$	Myrtenyl crotonate (560)
$C_{14}H_{20}O_3$	Ethyl camphorylideneacetate: P (559)
$C_{14}H_{20}O_4$	Methyl camphocarboxylate acetate: (414)
$C_{14}H_{20}O_6$	Diethyl dimethylsuccinylsuccinate: EtOH (235)
$C_{14}H_{21}NO_4$	Diethyl dihydrocollidinedicarboxylate (14); EtOH (386)
$C_{14}H_{22}O_2$	Butyrylcamphor (416)
$C_{14}H_{22}O_2$	Myrtenyl butyrate (560)
$C_{14}H_{24}O_3$	Menthyl acetoacetate: P (559)
$C_{15}H_8N_2O$	Ketohydrindenophenazine (516†)
$C_{15}H_9O_2$	Benzylidene phthalide: EtOH, H_2SO_4 (500)
$C_{15}H_{10}N_2O_3$	Benzeneazocarbonylcoumaranone: EtOH (+NaOEt) (457)
$C_{15}H_{10}O$	Phenylbenzoylacetylene: EtOH (619)

Formula	Name, solvents and literature
	Ultra-violet and Visible.—(*Continued*)
$C_{15}H_{11}NO_3$	Isonitrosodibenzoylmethane: EtOH, NaOEt (400)
$C_{15}H_{11}N_3O$	Quinolineazophenol: EtOH (159)
$C_{15}H_{11}N_3O$	5-Benzeneazo-8-hydroxyquinoline: EtOH, HCl (159)
$C_{15}H_{12}N_2$	Phenanthridine methocyanide: Et_2O, $CHCl_3$ (629)
$C_{15}H_{12}N_2$	3, 5-Diphenylpyrazole (554)
$C_{15}H_{12}N_2O_3$	Furfuramide: EtOH (273†)
$C_{15}H_{12}N_2O_3$	Benzenehydrazocarbonylcoumaranone: EtOH (+NaOH) (457)
$C_{15}H_{12}N_4O$	5-*p*-Aminobenzeneazo-8-hydroxyquinoline: EtOH (159)
$C_{15}H_{12}O$	Benzalacetophenone (534, 619)
$C_{15}H_{12}O_2$	α-Phenylcinnamic acid: EtOH (384)
$C_{15}H_{12}O_2$	Phenyl cinnamate (384)
$C_{15}H_{12}O_2S_2$	Diphenyl dithiomalonate: EtOH (536†)
$C_{15}H_{13}NO_3$	*p*-Nitro-*p'*-methoxystilbene: EtOH (315)
$C_{15}H_{13}N_3O_3$	*p*-Nitrobenzaldehyde phenylhydrazone, acetyl derivative: EtOH (314)
$C_{15}H_{14}$	α-Methylstilbene: EtOH (384, 393)
$C_{15}H_{14}N_2O_2$	*p*-Acetylbenzeneazo-*p*-cresol: EtOH (+NaOH) (316)
$C_{15}H_{14}N_2O_2$	Benzeneazophenyl propionate (196)
$C_{15}H_{14}O$	Benzylacetophenone: EtOH (619)
$C_{15}H_{14}O$	Dibenzyl ketone: EtOH (537)
$C_{15}H_{14}O$	Methoxystilbene: EtOH (315, 385)
$C_{15}H_{15}N_3O_2$	Nitroacetophenone phenylmethylhydrazone: EtOH (40)
$C_{15}H_{15}N_3O_4$	4, 6-Dinitro-3-*p*-toluidino-*o*-xylene: EtOH (477)
$C_{15}H_{15}N_3O_4$	3, 5-Dinitro-4-*p*-toluidino-*o*-xylene: EtOH (477)
$C_{15}H_{15}N_3O_4$	3, 5-Dinitro-4-benzylamino-*o*-xylene: EtOH (477)
$C_{15}H_{15}N_3O_5$	3, 5-Dinitro-4-*o*(*p*)-anisidino-*o*-xylene: EtOH (477)
$C_{15}H_{15}N_3O_5$	3, 5-Dinitro-6-*o*(*p*)-anisidino-*o*-xylene: EtOH (477)
$C_{15}H_{16}$	Phenyl-2, 4-xylylmethane: EtOH (537)
$C_{15}H_{16}N_2$	Benzylidene-*p*-dimethylaminoanil (337)
$C_{15}H_{16}N_2$	*p*-Dimethylaminobenzylideneanil (337)
$C_{15}H_{16}N_2O$	*s*-Dibenzylcarbamide: EtOH (522)
$C_{15}H_{16}N_2O$	Anisaldehyde phenylmethylhydrazone: EtOH (634)
$C_{15}H_{16}N_2O$	*o*-Methoxybenzaldehyde phenylmethylhydrazone: EtOH (634)
$C_{15}H_{16}N_2O$	*p*-Tolueneazo-*p*-cresetole: EtOH, HCl (633)
$C_{15}H_{16}N_2O$	Benzeneazophenyl propyl ether (196‡)
$C_{15}H_{16}N_4$	Pyruvaldehyde osazone (45)
$C_{15}H_{16}O_6$	Picrotoxinine: EtOH (264)
$C_{15}H_{17}BrN_2$	*p*-Dimethylaminobenzylideneanil hydrobromide (338)
$C_{15}H_{17}N_3$	Dimethyl-*o*-toluidineazobenzene: EtOH, HCl (233)
$C_{15}H_{17}N_3O$	*p*-Methoxybenzeneazodimethylaniline: EtOH, HCl (229, 318)
$C_{15}H_{17}N_3O_3S$	Dimethyl-*o*-toluidineazobenzenesulfonic acid: MeOH, EtOH + HCl (233)
$C_{15}H_{18}$	Azulene (365)
$C_{15}H_{18}ClN_3$	Benzeneazophenyltrimethylammonium chloride (229); H_2O, HCl (233)
$C_{15}H_{18}IN_3$	Benzeneazophenyltrimethylammonium iodide (229, 319); EtOH (29, 216); H_2SO_4, HCl (29)
$C_{15}H_{18}N_2O_2$	Phenylmethylhydrazodimethyldihydroresorcinol: EtOH (401)
$C_{15}H_{18}N_4O_2$	Antipyrine-4-azoethyl methyl ketone: EtOH (+NaOEt) (478)
$C_{15}H_{18}O_3$	Santonin: EtOH (448)
$C_{15}H_{18}O_5$	Diethylbenzoylsuccinate (24); EtOH (+NaOH) (23)
$C_{15}H_{21}NO_3$	Ethyl ethoxy-1, 1-dimethyl-Δ^3-cyclohexenylidene-5-cyanoacetate: EtOH (112)
$C_{15}H_{24}$	Caryophyllene: EtOH (225)
$C_{15}H_{24}O_3$	Diethyl camphocarboxylate (414)
$C_{15}H_{28}O_2$	Menthyl isopropylacetate (560)
$C_{16}H_8O_4$	Diphthalyl: AcOH (500)
$C_{16}H_9NO_2$	Cyanobenzalphthalid (500)
$C_{16}H_{10}$	Diphenyldiacetylene: EtOH (619)
$C_{16}H_{11}NO_2$	Diphenylmaleinimide: EtOH (389)
$C_{16}H_{11}NO_2$	1, 3-Diketo-2-benzylidenehydrindamine: EtOH, AcOH (516)
$C_{16}H_{11}NO_2$	2, 3-Diketo-4, 5-diphenylpyrroline: EtOH (512)
$C_{16}H_{11}NO_6$	Berberidic acid (287); H_2O (140)
$C_{16}H_{11}N_3O_3$	*o*(*m*, *p*)-Nitrobenzeneazo-α-naphthol: EtOH, NaOEt (44)
$C_{16}H_{11}N_3O_3S$	Diphenylthiovioluric acid: (402); Li salt: MeOH (402); K salt: Me_2CO (402†)
$C_{16}H_{11}N_3O_4$	Diphenylvioluric acid: $CHCl_3$ (228, 251); Alk. salt: Me_2CO, $CHCl_3$, AcOH (251); Cs salt: Me_2CO, $CHCl_3$ (228); Li salt: Me_2CO (228)
$C_{16}H_{12}$	Diphenylbutenine: EtOH (619)
$C_{16}H_{12}N_2$	2, 5(6)-Diphenylpyrazine (635)
$C_{16}H_{12}N_2O$	β-Naphthoquinone phenylhydrazone: EtOH, NaOEt (634)
$C_{16}H_{12}N_2O$	Benzeneazo-α(β)-naphthol: EtOH (+NaOEt) (183, 634)
$C_{16}H_{12}N_2O_3$	*p*-Tolueneazoformyloxycoumarone: EtOH (457)
$C_{16}H_{12}O_2$	Diphenyldiketocyclobutane: Et_2O (370,‡ 371‡)
$C_{16}H_{12}O_3$	Ethyl 9-ketofluorene-4-carboxylate: EtOH (616)
$C_{16}H_{13}BrN_2$	2, 5(6)-Diphenylpyrazine hydrobromide (635)
$C_{16}H_{13}ClN_2$	2, 5(6)-Diphenylpyrazine hydrochloride (635)
$C_{16}H_{13}N$	α(β)-Phenylnaphthylamine: *v.* p. 360
$C_{16}H_{14}$	Distyrene, solid and liquid: EtOH (622)
$C_{16}H_{14}$	Diphenylbutadiene: EtOH (619); *cf.* p. 360
$C_{16}H_{14}O_2S_2$	Diphenyl dithiosuccinate: EtOH (536†)
$C_{16}H_{14}O_3$	Ethyl *o*-benzoylbenzoate: EtOH (253)
$C_{16}H_{15}N$	Cinnamylidene-*p*-toluidine: EtOH (632)
$C_{16}H_{15}N_3O$	Phenyl styryl ketone semicarbazone (295)
$C_{16}H_{16}$	*p*-Dimethylstilbene: EtOH (393)
$C_{16}H_{16}$	α, β-Dimethylstilbene: EtOH (393)
$C_{16}H_{16}N_2O_2$	Benzeneazophenyl butyrate (196‡)
$C_{16}H_{18}$	Diphenylbutane: EtOH (393, 619)
$C_{16}H_{18}N_2$	Cuminal phenylhydrazone: EtOH (+AcOH) (620)
$C_{16}H_{18}N_2O$	Benzeneazophenyl butyl ether (196‡)
$C_{16}H_{18}N_2O_2$	Azophenetole: EtOH (+NaOEt) (634)
$C_{16}H_{18}N_2O_3$	Azoxyphenetole: EtOH (526†)
$C_{16}H_{18}N_4$	Diacetyl phenylosazone: EtOH (45)
$C_{16}H_{18}N_4$	Glyoxal phenylmethylosazone (45)
$C_{16}H_{18}N_4O_3$	Antipyrine-4-azoacetylacetone: EtOH (+NaOEt) (478)

Formula	Name, solvents and literature
	Ultra-violet and Visible.—(*Continued*)
$C_{16}H_{19}BrN_2O$	Camphorquinone *p*-bromophenylhydrazone: EtOH, NaOEt (45)
$C_{16}H_{19}Br_2NO_3S$	α-Bromocamphor-β-sulfon-*p*-bromoanilide: EtOH + NaOEt (413)
$C_{16}H_{19}NO_4$	Benzoylecgonine: *v.* p. 360
$C_{16}H_{19}N_3$	*p*-Azotoluenedimethylamine: EtOH (247)
$C_{16}H_{20}N_2O$	α(β)-Camphorquinone phenylhydrazone: (368); EtOH, NaOEt (45)
$C_{16}H_{20}O_2$	Tetraallyldiketocyclobutane: (371‡); hexane (370‡)
$C_{16}H_{21}NO_3$	Homoatropine: *v.* p. 360
$C_{16}H_{21}NO_3S$	Camphor-β-sulfonanilide: EtOH, +NaOEt (413)
$C_{16}H_{22}$	Dimethylphenyloctadiene (560)
$C_{16}H_{22}O$	Benzoyltetramethylcyclopentane: P (559)
$C_{16}H_{24}BrNO_2$	Bromocamphorcarboxylic piperidide (414)
$C_{16}H_{25}ClO_3$	Amyl chlorocamphorcarboxylate (414)
$C_{16}H_{25}NO_2$	Camphocarboxylic piperidide (414)
$C_{16}H_{26}O_3$	Amyl camphocarboxylate: NaOEt (414)
$C_{16}H_{26}O_4$	Menthyl diacetoacetate: C_6H_6 (559)
$C_{16}H_{28}O_2$	Tetrapropyldiketocyclobutane: hexane (370‡, 371‡)
$C_{16}H_{34}O$	Cetyl alcohol (438)
$C_{17}H_{11}NO_4$	2, 3-Diketo-4-phenyl-5-piperonylpyrroline: EtOH (512)
$C_{17}H_{12}N_2O_4$	Benzeneazocarbonyl-2-acetylcoumaranone: EtOH (457)
$C_{17}H_{12}O_3$	8-Phenylindoneacetic acid: EtOH (616)
$C_{17}H_{12}O_4$	Bis(furfurylidenemethyl)-pyrone: EtOH (76)
$C_{17}H_{13}ClO_4$	Bis(furfurylidenemethyl)pyrone hydrochloride: HCl, EtOH (76)
$C_{17}H_{13}NO_2$	2, 3-Diketo-4-phenyl-5-*o*(*m*, *p*)-tolylpyrroline: EtOH (512)
$C_{17}H_{13}NO_3$	1, 3-Diketo-2-anisylidenehydrindamine: AcOH (516)
$C_{17}H_{13}NO_3$	2, 3-Diketo-4-phenyl-5-*p*-anisylpyrroline: EtOH (512)
$C_{17}H_{13}N_3$	2(3), *p*-Tolyl-α, β-naphtho-(iso)triazole: EtOH (473)
$C_{17}H_{13}N_3O_6S$	Toluene-*p*-sulfonyl-1, 6-dinitro-β-naphthylamine: EtOH (472)
$C_{17}H_{14}N_2O$	α-Naphthoquinone phenylmethylhydrazone: EtOH (634)
$C_{17}H_{14}N_2O_4S$	Toluene-*p*-sulfonyl-1-nitro-β-napthylamine: EtOH (472)
$C_{17}H_{14}O$	Dibenzalacetone (410, 411); EtOH, H_2SO_4 (13, 406); AcOH + H_2SO_4, $CHCl_3$ + $SnCl_4$ (406)
$C_{17}H_{14}O$	Cinnamylideneacetophenone: EtOH (614)
$C_{17}H_{14}O_4$	Ethyl benzil-*o*-carboxylate: EtOH (253)
$C_{17}H_{16}N_2$	α-*p*-Toluidino-γ-phenylisocrotononitrile: Et_2O (632)
$C_{17}H_{16}N_2O_3$	Ethyl phenylhydrazinocoumaranonecarboxylate: EtOH (457)
$C_{17}H_{17}ClN_2$	α-*p*-Toluidino-γ-phenylisocrotononitrile hydrochloride: EtOH (632)
$C_{17}H_{17}NO_2$	Apomorphine (195‡); EtOH + HCl (264)
$C_{17}H_{18}ClNO_2$	Apomorphine hydrochloride: EtOH (264, 606‡)
$C_{17}H_{19}NO_3$	Piperine: EtOH (136, 264); Vap. (520)
$C_{17}H_{19}NO_3$	Morphine: (137, 195‡); EtOH (140, 264, 287, 606‡); HCl, NaOH (75)
$C_{17}H_{19}N_3O_2$	Ethyl dimethylanilineazobenzoate: EtOH (229)
$C_{17}H_{20}N_2O$	4, 4′-Tetramethyldiaminobenzophenone: EtOH (30, 201†, 409); HCl (30)
$C_{17}H_{20}N_2O_2$	*p*-Dimethylaminobenzylideneanil acetate (337)
$C_{17}H_{20}N_4O_4$	Ethyl antipyrine-4-azoacetoacetate: EtOH (+NaOEt) (478)
$C_{17}H_{20}O$	Benzylidenecamphor (416, 534, 560); EtOH (214, 415‡)
$C_{17}H_{20}O_2$	*m*-Hydroxybenzylidenecamphor: EtOH (214)
$C_{17}H_{21}NO_2$	Apoatropine (194‡)
$C_{17}H_{21}NO_4$	Hyoscine: EtOH (136)
$C_{17}H_{21}NO_4$	Cocaine (194‡); EtOH (95‡, 136)
$C_{17}H_{21}N_3O_2$	α(β)-Camphorquinone phenylcarbamylhydrazone (368)
$C_{17}H_{22}ClNO_4$	Cocaine hydrochloride: EtOH (95‡); *cf.* p. 360
$C_{17}H_{22}N_2O$	Camphorquinone phenylmethylhydrazone (45)
$C_{17}H_{22}N_6O_4$	*o*-Nitrobenzenediazo-4-semicarbazinocamphor (157)
$C_{17}H_{23}NO_3$	Atropine (194‡); EtOH (136)
$C_{17}H_{23}NO_3$	Hyoscyamine: EtOH (136)
$C_{17}H_{25}NO_7S$	Hyoscyamine bisulfate: H_2O (95‡)
$C_{17}H_{26}O_2$	Myrtenyl hexahydrobenzoate (560)
$C_{18}H_9ClO_3$	1-Chloro-6-hydroxynaphthacenequinone: EtOH, NaOEt, H_2SO_4, H_3BO_3 (41)
$C_{18}H_9NO_4$	Diketohydrindylidenediketohydrindamine: AcOH (516); NH_4 salts (516)
$C_{18}H_9N_2O_7$	1-Hydroxy-2, 6-dinitronaphthacenequinone: EtOH, NaOEt, H_2SO_4, H_3BO_3 (41)
$C_{18}H_{10}O_2$	Naphthacenequinone: EtOH, NaOEt, H_2SO_4, H_3BO_3 (41)
$C_{18}H_{10}O_3$	*allo*-Chrysoketone-1-carboxylic acid: EtOH (238, 616); H_2SO_4, AcOH (238)
$C_{18}H_{10}O_3$	1-Hydroxynaphthacenequinone: EtOH, NaOEt, H_2SO_4, H_3BO_3 (41)
$C_{18}H_{10}O_4$	1, 6(7, 8, 9, 10)-Dihydroxynaphthacenequinone: EtOH, NaOEt, H_2SO_4, H_3BO_3 (41)
$C_{18}H_{10}O_5$	1, 2, 6-Trihydroxynaphthacenequinone: EtOH, NaOEt, H_2SO_4, H_3BO_3 (41)
$C_{18}H_{10}O_7S$	1, 5-Dihydroxynaphthacenequinonesulfonic acid: EtOH, NaOEt, H_2SO_4, H_3BO_3 (41)
$C_{18}H_{11}Cl_3N_2$	Dichlorophenylphenazonium chloride: EtOH (16)
$C_{18}H_{11}NO_2$	Quinophthalone: EtOH (489.5)
$C_{18}H_{11}NO_3$	1-Amino-6-hydroxynaphthacenequinone: EtOH, NaOEt, H_2SO_4, H_3BO_3 (41)
$C_{18}H_{11}NO_4$	1-Amino-6, 8(9)-dihydroxynaphthacenequinone: EtOH, NaOEt, H_2SO_4, H_3BO_3 (41)
$C_{18}H_{11}NO_8S_2$	Quinophthalonedisulfonic acid, Na salt (489.5)
$C_{18}H_{12}$	Chrysene (42); EtOH (431‡)
$C_{18}H_{12}N_2O_2$	Hydroxyaposafranone: NaOH, HCl (16)
$C_{18}H_{12}N_4O$	Quinolineazo-8-hydroxyquinoline: EtOH (159)
$C_{18}H_{12}N_6O_3$	*p*′-Nitro-*p*″-hydroxy-*p*-bisazobenzene: EtOH (496); Na salt: (496)
$C_{18}H_{14}ClN_3$	Aminophenylphenazonium chloride: H_2O (289)
$C_{18}H_{14}N_2O$	Benzeneazophenyl phenyl ether (196‡)
$C_{18}H_{14}N_2O_2$	*p*-Acetylbenzeneazo-α(β)-naphthol: EtOH (+NaOH) (316)
$C_{18}H_{14}N_2O_2$	Acetyl-β-naphthoquinone phenylhydrazone: (634)
$C_{18}H_{14}N_2O_2$	Benzeneazo-α(β)-naphthyl acetate: EtOH (634)
$C_{18}H_{14}N_2O_4$	*dl*-*m*-Azo-β-naphtholmandelic acid: EtOH, NaOH (83.5)
$C_{18}H_{14}O_3$	Methyl γ-phenylindoneacetate: EtOH (616)
$C_{18}H_{14}O_6$	Monoethyl benzil-*o*-dicarboxylate (keto and lactone forms): EtOH (253)
$C_{18}H_{15}As$	Arsenic triphenyl: $CHCl_3$ (537)

Formula	Name, solvents and literature
	Ultra-violet and Visible.—(*Continued*)
$C_{18}H_{15}ClN_4$	Phenosafranine chloride: H_2O, HCl (16)
$C_{18}H_{16}N$	Triphenylamine (410); EtOH (13)
$C_{18}H_{15}O_4P$	Triphenyl phosphate: EtOH; Vap. (242)
$C_{18}H_{15}P$	Triphenylphosphine: EtOH, Vap. (242)
$C_{18}H_{16}N_2$	Diphenyl-*p*-phenylenediamine (410)
$C_{18}H_{16}N_2O$	Benzeneazo-α-naphthyl ethyl ether: EtOH (634)
$C_{18}H_{16}N_2O_2$	1, 3-Diketo-2-*p*-dimethylaminobenzylidenehydrindamine: AcOH (516)
$C_{18}H_{16}N_2O_2$	*p*, *p*′-Dimethoxy-2, 5(6)-diphenylpyrazine: $CHCl_3$ (635)
$C_{18}H_{16}N_2O_4S$	Toluene-*p*-sulfonylmethyl-1-nitro-β-naphthylamine: EtOH (472)
$C_{18}H_{16}O_2$	Dimethyldiphenyldiketocyclobutane: hexane (370‡, 371‡)
$C_{18}H_{16}O_2$	Benzylideneanisylideneacetone: EtOH, H_2SO_4 (13)
$C_{18}H_{16}O_4$	α-Truxillic acid: EtOH (614, 617)
$C_{18}H_{16}O_4$	β-Truxillic acid: EtOH (617)
$C_{18}H_{17}BrN_2O_2$	*p*, *p*′-Dimethoxy-2, 5(6)-diphenylpyrazine hydrobromide: $CHCl_3$ (635)
$C_{18}H_{17}ClN_2O_2$	*p*, *p*′-Dimethoxy-2, 5(6)-diphenylpyrazine hydrochloride: $CHCl_3$ (635)
$C_{18}H_{17}NO_6$	Corydic acid: H_2O (140, 287)
$C_{18}H_{18}$	Retene: (191†)
$C_{18}H_{20}O_3$	Piperonylidenecamphor (214)
$C_{18}H_{21}NO_3$	Codeine (140†, 195‡, 264); EtOH (606‡)
$C_{18}H_{22}BrNO_4$	*o*-Hydroxycodeine hydrobromide: H_2O (142†)
$C_{18}H_{22}ClNO_3$	Codeine hydrochloride: H_2O (606‡)
$C_{18}H_{22}N_4O_4$	Glucosazone (45)
$C_{18}H_{22}O$	*m*(*p*)-Tolylidenecamphor: EtOH (214)
$C_{18}H_{22}O_2$	*m*-Methoxybenzylidenecamphor: EtOH (214)
$C_{18}H_{22}O_2$	Anisylidenecamphor: EtOH (214)
$C_{18}H_{23}N_3O$	Dipropylaminobenzeneazophenol: $CHCl_3$ (250)
$C_{18}H_{24}O_2$	Anisylcamphor: EtOH (214)
$C_{18}H_{26}N_6O_2$	*p*-Toluenediazo-ψ-semicarbazinocamphor (157)
$C_{18}H_{26}OS_2$	Benzyl menthylxanthogenate: EtOH (97)
$C_{18}H_{28}O_4$	Amyl camphorcarboxylate acetate (414)
$C_{18}H_{28}O_4$	Ethyl camphorcarboxylate valerate (414)
$C_{18}H_{32}O_2$	Stearolic acid (423)
$C_{18}H_{32}O_3$	Menthyl α, α-diethylacetoacetate: C_6H_6 (559)
$C_{18}H_{34}O_2$	Elaidic acid (423)
$C_{18}H_{36}O_2$	Stearic acid (423)
$C_{19}H_{12}O_4$	1-Hydroxy-5(8)-methoxynaphthacenequinone: EtOH, NaOEt, H_2SO_4, H_3BO_3 (41)
$C_{19}H_{13}BrN_2O_4$	Bromodinitrotriphenylmethane: EtOH (244); Na salt: EtOH + C_6H_6 (244)
$C_{19}H_{13}N$	Fluorenoneanil: $CHCl_3$ (543)
$C_{19}H_{13}N$	Phenylacridine: $CHCl_3$, EtOH (223)
$C_{19}H_{13}N_3O_6$	Trinitrotriphenylmethane: $CHCl_3$ (244); Na salt: EtOH + C_6H_6 (244)
$C_{19}H_{13}N_3O_7$	*p*-Trinitrotriphenylcarbinol: $CHCl_3$, MeOH (239)
$C_{19}H_{14}ClN$	Fluorenoneanil hydrochloride: $CHCl_3$ (534)
$C_{19}H_{14}N_2O$	Benzoylazobenzene: EtOH (457)
$C_{19}H_{14}N_2O_2$	Benzeneazophenyl benzoate (196‡)
$C_{19}H_{14}N_2O_2$	*p*-Benzoquinone benzoylphenylhydrazone (633)
$C_{19}H_{14}N_2O_2$	*p*-Benzoylbenzeneazophenol (633); EtOH (+NaOH) (316)
$C_{19}H_{14}N_4O_2$	*p*-Nitrobenzylideneaminoazobenzene (496)
$C_{19}H_{14}O$	Fuchsone (5.6, 228, 483.4, 579)
$C_{19}H_{14}O_2$	Benzaurin: EtOH, HCl (483.4, 484.3)
$C_{19}H_{14}O_3$	Aurin: KOH, EtOH, HCl (483.4)
$C_{19}H_{14}O_5S$	Phenolsulfonephthalein: EtOH, KOH (333‡)
$C_{19}H_{15}Cl$	Triphenylchloromethane: EtOH (13, 406, 483.3); $CHCl_3$ + $SnCl_4$ (406); Et_2O (5.5)
$C_{19}H_{15}N$	Diphenylmethylidenephenylimine (337)
$C_{19}H_{15}N$	Dihydrophenylacridine (146)
$C_{19}H_{15}N$	Benzophenoneanil: $CHCl_3$ (543)
$C_{19}H_{15}NO_2$	*p*-Nitrotriphenylmethane and Na salt: EtOH (244)
$C_{19}H_{15}NO_2$	Phenyl diphenylcarbamate: EtOH, Vap. (522)
$C_{19}H_{15}NO_5S$	Phenylacridonium sulfate: EtOH (223)
$C_{19}H_{15}N_3$	Benzylideneaminoazobenzene (496)
$C_{19}H_{16}$	Triphenylmethane: EtOH (13, 443†, 483.3); Et_2O (5.5)
$C_{19}H_{16}BrN$	Diphenylmethylidenephenylimine hydrobromide (337)
$C_{19}H_{16}ClN$:	Benzophenoneanil hydrochloride: $CHCl_3$ (543)
$C_{19}H_{16}IN$	Diphenylmethylidenephenylimine hydroiodide (337)
$C_{19}H_{16}O$	Triphenylcarbinol (419.2); H_2SO_4 (13); EtOH (13, 483.3); Et_2O (5.5)
$C_{19}H_{16}O$	*p*-Hydroxytriphenylmethane (5.6)
$C_{19}H_{16}O_2$	*p*-Hydroxytriphenylcarbinol (5.6)
$C_{19}H_{16}O_4S$	Triphenylcarbonium sulfate (228, 406, 579)
$C_{19}H_{17}NO_2$	2, 3-Diketo-4-phenyl-5-*p*-cumylpyrroline: EtOH (512)
$C_{19}H_{17}N_3$	Triphenylguanidine: EtOH (522)
$C_{19}H_{18}IP$	Triphenylmethylphosphonium iodide: EtOH, $CHCl_3$, H_2O (242)
$C_{19}H_{18}O_3$	Dianisylideneacetone: EtOH, H_2SO_4 (13, 406); $CHCl_3$ + $SnCl_4$ (406)
$C_{19}H_{19}NO_4$	Bulbocapnine (140); EtOH (287)
$C_{19}H_{21}NO_3$	Thebaine: EtOH (264)
$C_{19}H_{22}ClNO_3$	Thebaine hydrochloride: H_2O (606‡)
$C_{19}H_{22}N_2O$	Cinchonidine (140†); EtOH (264)
$C_{19}H_{22}N_2O$	Cinchotoxine: *v.* p. 360
$C_{19}H_{22}N_2O$	Cinchonine (264); EtOH (140, 143, 287); (+HCl) (143); *cf.* p. 360
$C_{19}H_{22}N_2O_2$	Cupreine (140†); EtOH (135)
$C_{19}H_{22}N_2O_2.2H_2O$	Apoquinine: *v.* p. 360
$C_{19}H_{22}N_2O_4$	Quitenine: *v.* p. 360
$C_{19}H_{22}O$	Cinnamylidene camphor (534)
$C_{19}H_{23}ClN_2O$	Cinchonine hydrochloride; *v.* p. 360
$C_{19}H_{24}N_2O_2$	Hydrocupreine: *v.* p. 360
$C_{19}H_{26}O_3$	Menthyl benzoylacetate: C_6H_6 (559)
$C_{19}H_{28}O_2$	Menthyl hydrocinnamate (560)
$C_{20}H_6Br_4Cl_4O_4$	Tetrabromophenoltetrachlorophthalein: EtOH, KOH (333‡)
$C_{20}H_6Cl_4I_4O_4$	Tetraiodophenoltetrachlorophthalein (333‡)
$C_{20}H_8Br_4O_5$	Eosin: H_2O (439); alk. (467); EtOH (482‡)
$C_{20}H_8I_4O_5$	Erythrosin: H_2O (439)
$C_{20}H_{10}Br_4O_4$	Tetrabromophenolphthalein: EtOH, KOH (333‡); NaOH (462, 467); Neutral alkali salts (462)
$C_{20}H_{10}Cl_2O_3$	Dichlorofluoran: EtOH (484.2)
$C_{20}H_{10}Cl_4O_4$	Tetrachlorophenolphthalein: EtOH, KOH (184, 333‡)
$C_{20}H_{10}I_4O_4$	Tetraiodophenolphthalein: EtOH, KOH (333‡)
$C_{20}H_{12}O_3$	Fluoran: EtOH, H_2SO_4 (484.2)
$C_{20}H_{12}O_5$	Fluorescein (462); H_2O (439,† 466); EtOH, AcOH, H_2SO_4, HCl, KOH (484.2); Neutral alk. salts (462); Na salt: H_2O (466)
$C_{20}H_{14}$	Benzylidenefluorene: EtOH (392)
$C_{20}H_{14}$	β, β-Dinaphthyl: EtOH, C_6H_6 (323)

Formula	Name, solvents and literature
	Ultra-violet and Visible.—(*Continued*)
$C_{20}H_{14}N_2O$	α, α-Azoxynaphthalene, (*two forms*): EtOH (121)
$C_{20}H_{14}O$	Benzoylfluorene: EtOH (392)
$C_{20}H_{14}O$	Diphenylenephenylvinyl alcohol: EtOH (392)
$C_{20}H_{14}O_2$	Phthalophenone: EtOH, H_2SO_4 (500)
$C_{20}H_{14}O_2$	Diphenylphthalide: EtOH, H_2SO_4, KOH (483.2)
$C_{20}H_{14}O_2$	Terephthalophenone: EtOH, ligroin (71)
$C_{20}H_{14}O_2S$	β-Naphthol sulfides: EtOH (115)
$C_{20}H_{14}O_3$	Ethyl *allo*-chrysoketone-1-carboxylate: EtOH (616)
$C_{20}H_{14}O_3$	Hydroxydiphenylphthalide: EtOH, H_2SO_4 (462, 463); Neutral alk. salts (462, 463)
$C_{20}H_{14}O_4$	Phenolphthalein (462); EtOH, KOH (333‡); H_2SO_4 (463, 465); $CHCl_3 + SnCl_4$ (463); H_2O, Na salt (466); NaOH (467); Neutral alk. salts (462, 463)
$C_{20}H_{14}O_4$	Isophenolphthalein (483.2)
$C_{20}H_{14}O_4$	Diphenyl phthalate: EtOH (522)
$C_{20}H_{16}$	α-Phenylstilbene: EtOH (384); $CHCl_3$ (392, 393)
$C_{20}H_{16}ClN$	Phenylacridonium methochloride: $CHCl_3$, HCl (223)
$C_{20}H_{16}IN$	Phenylacridonium methiodide: $CHCl_3$ (223)
$C_{20}H_{16}N_2O$	Benzilphenylhydrazone: EtOH (+NaOEt) (45)
$C_{20}H_{16}N_2O_2$	*o*-Benzoylbenzeneazo-*p*-cresol: EtOH (633)
$C_{20}H_{16}N_2O_2$	*p*-Benzoylbenzeneazocresol: EtOH (+NaOH) (316)
$C_{20}H_{16}O$	Triphenylvinyl alcohol: $CHCl_3$ (392)
$C_{20}H_{16}O$	Fuchsone of *o*-cresyldiphenylcarbinol (5.6)
$C_{20}H_{16}O_2$	Triphenylacetic acid: EtOH (522)
$C_{20}H_{16}O_6$	Quinolphthalein, alkali salts (462); NaOH (467); H_2O (466)
$C_{20}H_{17}NO$	*N*-Methylphenylacridol: MeOH, $CHCl_3$, Et_2O (146); Salts (215‡)
$C_{20}H_{17}N_3O$	*p*-Methoxybenzylideneaminoazobenzene (496)
$C_{20}H_{18}ClNO_4$	Berberine chloride: EtOH, +KOH (630); H_2O (606‡)
$C_{20}H_{18}N_2$	Desoxybenzoin phenylhydrazone (45)
$C_{20}H_{18}N_2O$	α(β)-Benzoin phenylhydrazone (45)
$C_{20}H_{18}N_2O_2$	1, 2- Diketo- 5-acetyl- 3- phenyl- 4- methyl- Δ^3-cyclopentene phenylhydrazone: EtOH (513)
$C_{20}H_{18}N_2O_7$	Berberine nitrate: H_2O (140)
$C_{20}H_{18}N_4$	Phenylglyoxalosazone (45)
$C_{20}H_{18}N_4O$	*p*-Acetylbenzeneazophenol phenylhydrazone: EtOH + NaOH (316)
$C_{20}H_{18}O_2$	3-Methyl-4-hydroxytriphenylcarbinol (5.6)
$C_{20}H_{18}O_5$	Dimethyl β-benzoyl-γ-phenylvinylmalonate: EtOH (92)
$C_{20}H_{18}O_5$	Dimethyl 3-benzoyl-2-phenylcyclopropanedicarboxylate: EtOH (92)
$C_{20}H_{19}NO_5$	Berberine (287); EtOH (606‡, 630†); H_2O (630†)
$C_{20}H_{20}ClN_3$	Fuchsine: dil. HCl (229, 233)
$C_{20}H_{20}N_2O_4$	*m*, *m'*, *p*, *p'*-Tetramethoxy-2, 6-diphenylpyrazine: $CHCl_3$ (635)
$C_{20}H_{20}O_5$	Dimethyl γ-benzoyl-β-phenylethylmalonate: EtOH (92)
$C_{20}H_{21}BrN_2O_4$	*m*, *m'*, *p*, *p'*-Tetramethoxy-2, 6-diphenylpyrazine hydrobromide: $CHCl_3$ (635)
$C_{20}H_{21}ClN_2O_4$	*m*, *m'*, *p*, *p'*-Tetramethoxy-2, 6-diphenylpyrazine hydrochloride: $CHCl_3$ (635)
$C_{20}H_{21}Cl_2N_3$	Fuchsine hydrochloride (228)
$C_{20}H_{21}NO_4$	Papaverine: EtOH (140, 264, 287, 606‡)
$C_{20}H_{21}NO_4$	Tetrahydroberberine (137†); EtOH (140, 287)
$C_{20}H_{22}ClNO_4$	Papaverine hydrochloride: H_2O (606‡)
$C_{20}H_{22}N_2O_2$	1, 4-Dibenzoyl-2(3)-dimethylpiperazine: EtOH (520)
$C_{20}H_{22}N_2O_2$	Hydroquininone: *v.* p. 360
$C_{20}H_{22}O_2$	Camphorylidenebenzylideneacetone: C_6H_6 (559)
$C_{20}H_{24}N_2O_2$	Chinotoxine: *v.* p. 360
$C_{20}H_{24}N_2O_2$	Quinine (135, 140, 143, 264, 287); *cf.* p. 360
$C_{20}H_{24}N_2O_2$	Quinidine (140, 264)
$C_{20}H_{24}N_2O_2$	Isoquinine: *v.* p. 360
$C_{20}H_{24}O_4$	Ethyl camphorcarboxylate benzoate (414)
$C_{20}H_{25}ClN_2O_2$	Quinine hydrochloride (135); *cf.* p. 360
$C_{20}H_{25}NO_4$	Laudanine: EtOH (139, 141)
$C_{20}H_{25}NO_4$	Tetrahydropapaverine (137,†287); EtOH (140)
$C_{20}H_{26}N_2$	Ethylidenexylidine (507)
$C_{20}H_{26}N_2O_2$	Hydrochinotoxine: *v.* p. 360
$C_{20}H_{28}N_2O_5$	Nitrocamphor anhydride: EtOH (412)
$C_{20}H_{28}N_4O_4$	Glucosemethylosazone (45)
$C_{21}H_{16}N_2$	Phenylacridine methocyanide: Et_2O, $CHCl_3$ (629)
$C_{21}H_{16}N_4O$	Triketohydrindene diphenylhydrazone: EtOH (516)
$C_{21}H_{16}O$	Benzylidenedesoxybenzoin (534)
$C_{21}H_{16}O_2$	α, α'-Distyryl-γ-pyrone: EtOH, H_2SO_4 (76)
$C_{21}H_{17}ClO_2$	α, α'-Distyryl-γ-pyrone hydrochloride: EtOH, HCl (76)
$C_{21}H_{18}N_2O$	Benzil phenylmethylhydrazone (45)
$C_{21}H_{18}N_2O_2$	Benzoylbenzeneazo-*p*-cresetole (633)
$C_{21}H_{18}O$	Dicinnamylideneacetone (410); EtOH, $CHCl_3$ + $SnCl_4$, H_2SO_4 (+AcOH) (406)
$C_{21}H_{18}O_5S$	*o*-Cresolsulfonephthalein: H_2O, acid, alk. (484‡)
$C_{21}H_{18}S_3$	Trithiobenzaldehyde (534)
$C_{21}H_{20}ClN_5O$	Antipyrine-4-azonaphthylamine hydrochloride: EtOH (478)
$C_{21}H_{20}ClN_5O_4S$	Antipyrine-4-azo-β-naphthylamine-6'-sulfonic acid hydrochloride: EtOH (478)
$C_{21}H_{20}N_4$	Phenylglyoxalmethylosazone (45)
$C_{21}H_{20}N_4O_3$	Antipyrine-4-azobenzoylacetone: EtOH, +NaOEt (478)
$C_{21}H_{20}O$	Triphenylcarbinyl ethyl ether: Et_2O (5.5,
$C_{21}H_{20}O_3$	*o*-Cresolbenzein: EtOH, HCl, H_2SO_4, KOH (484.3)
$C_{21}H_{20}O_5$	Dimethyl 2-phenyl-3-methylbenzoylcyclopropanedicarboxylate: EtOH (92)
$C_{21}H_{20}O_6$	Dimethyl β-anisoyl-γ-phenylvinylmalonate: EtOH (92)
$C_{21}H_{20}O_6$	Dimethyl 3-anisoyl-2-phenylcyclopropanedicarboxylate: EtOH (92)
$C_{21}H_{21}N$	Tribenzylamine: Et_2O (522)
$C_{21}H_{21}NO_4$	Methyldihydroberberine: EtOH (630)
$C_{21}H_{21}NO_5$	Hydrastine: EtOH (140, 287, 603‡); Et_2O (603‡); H_2O (606‡)
$C_{21}H_{21}O_4P$	Tri-*o*(*p*)-tolyl phosphate: EtOH (522)
$C_{21}H_{22}ClNO_4$	Methyldihydroberberine hydrochloride: EtOH (630)
$C_{21}H_{22}N_2O_2$	Strychnine: EtOH (264)
$C_{21}H_{22}O_5$	Dimethyl benzoylphenylpropylmalonate: EtOH (92)
$C_{21}H_{22}O_6$	Dimethyl γ-anisoyl-β-phenylethylmalonate: EtOH (92)

Formula	Name, solvents and literature
	Ultra-violet and Visible.—(*Continued*)
$C_{21}H_{23}NO_5$	Cryptopine (137)
$C_{21}H_{24}ClNO_4$	Heroine hydrochloride: H_2O (606‡)
$C_{21}H_{24}ClNO_5$	Cryptopine hydrochloride (137)
$C_{21}H_{24}O_{10}$	Phlorizine (286)
$C_{21}H_{25}NO_4$	Corybulbine: EtOH (140, 287)
$C_{21}H_{26}N_2O_3$	Yohimbine: *v.* p. 360
$C_{21}H_{27}NO_4$	Laudanosine (137†); EtOH (139, 141)
$C_{21}H_{28}N_2O_2$	Optoquinine: *v.* p. 360
$C_{21}H_{28}O_3$	Menthyl benzylideneacetoacetate: C_6H_6 (559)
$C_{21}H_{30}O_3$	Menthyl benzylacetoacetate: C_6H_6 (559)
$C_{22}H_{14}$	Picene: C_6H_6 (323, 325)
$C_{22}H_{14}$	Dinaphthanthracene: C_6H_6 (323, 325)
$C_{22}H_{14}O_6$	1, 8(9)-Diacetoxynaphthacenequinone: EtOH, NaOEt, H_2SO_4, H_3BO_3 (41)
$C_{22}H_{15}N_3$	4, 5-Diphenylpyrrolinophenazine: EtOH (512)
$C_{22}H_{16}ClN_3$	Aminophenylnaphthophenazonium chloride: H_2O (289)
$C_{22}H_{17}N_3O$	2, 3-Diketo-4, 5-diphenylpyrroline phenylhydrazone: EtOH (512)
$C_{22}H_{18}O_2$	Triphenylvinyl acetate: $CHCl_3$ (392)
$C_{22}H_{18}O_4$	Phenolphthalein dimethyl ether and esters: $CHCl_3$ + $SnCl_4$, H_2SO_4 (465)
$C_{22}H_{19}NO_2$	Dimethylisopropylquinophthalone: EtOH (489.5)
$C_{22}H_{19}NO_8S_2$	Dimethylisopropylquinophthalonesulfonic acid, Na salt: H_2O (489.5)
$C_{22}H_{19}N_3O$	Phenyl styryl ketone phenylsemicarbazone: EtOH (+NaOEt) (296)
$C_{22}H_{21}ClO_3$	Trimethoxytriphenylcarbinyl chloride: (419.2)
$C_{22}H_{22}O_3$	Trianisylmethane: EtOH (13)
$C_{22}H_{22}O_4$	Trianisylcarbinol: H_2SO_4 (13, 406)
$C_{22}H_{22}O_4$	Trimethoxytriphenylcarbinol: H_2O + Me_2CO + acid (419.2)
$C_{22}H_{22}O_6$	Diethyl α (β, γ)-dibenzoylsuccinate: EtOH (234)
$C_{22}H_{23}NO_7$	Gnoscopine (140†)
$C_{22}H_{23}NO_7$	Narcotine: EtOH (140, 264, 287, 603‡, 605‡, 606‡); Et_2O (603‡)
$C_{22}H_{23}NO_8$	Hydroxynarcotine: EtOH + AcOH (264)
$C_{22}H_{24}N_2O$	Camphorquinone diphenylhydrazone (45)
$C_{22}H_{25}NO_5$	Diacetylcodeine: EtOH (264)
$C_{22}H_{26}N_2O_8$	Dehydrocorydaline nitrate: H_2O (140, 287)
$C_{22}H_{27}NO_4$	Corydaline (137†); EtOH (140, 287)
$C_{22}H_{34}O_2S_3$	Fenchylxanthic acid thioanhydride (97)
$C_{22}H_{34}O_2S_3$	Bornylxanthic acid thioanhydride: EtOH (97)
$C_{22}H_{34}O_2S_4$	Bornyl dixanthogenide: EtOH (97)
$C_{22}H_{34}O_2S_4$	Fenchyldixanthogenide (97)
$C_{22}H_{40}O_2$	Behenolic acid (423)
$C_{22}H_{42}O_2$	Erucic acid (423, 424)
$C_{22}H_{42}O_2$	Isoerucic acid (424)
$C_{22}H_{42}O_2$	Brassidic acid (424)
$C_{23}H_{16}N_2O_2$	*p*-Benzoylbenzeneazo-α(β)-naphthol: EtOH (+NaOH) (316)
$C_{23}H_{16}O_2$	1, 3-Dibenzoyl-2-phenylcyclopropene: EtOH (92)
$C_{23}H_{17}N_3$	4-Phenyl-5, *p*-tolylpyrrolinophenazine: EtOH (512)
$C_{23}H_{18}N_4O_3$	Benzeneazoacetylcarbonylcoumaranone phenylhydrazone: EtOH (457)
$C_{23}H_{18}O_2$	1, 3-Dibenzoyl-2-phenylcyclopropane: EtOH (92)
$C_{23}H_{19}N_3O$	2, 3-Diketo-4-phenyl-5, *p*-tolylpyrroline phenylhydrazone: EtOH (512)

Formula	Name, solvents and literature
$C_{23}H_{20}Br_4O_4$	Bis(α, β-dibromoanisylmethyl)pyrone: EtOH (+NaOEt) (76)
$C_{23}H_{20}O_2$	α, γ-Dibenzoyl-β-phenylpropane: EtOH (92)
$C_{23}H_{20}O_4$	Bis(anisylidenemethyl)pyrone: EtOH, AcOH (76)
$C_{23}H_{21}ClO_4$	Bis(anisylidenemethyl)pyrone hydrochloride: EtOH, $CHCl_3$ (76)
$C_{23}H_{22}N_4O_3$	*dl*(*d* and *l*)-Phenyl(*p*-dimethylaminobenzene azobenzoylaminoacetic acid: EtOH (83.4)
$C_{23}H_{22}O_3$	Dimethoxycinnamylideneacetone: H_2SO_4 (+AcOH) (406)
$C_{23}H_{23}N_5O$	Antipyrine-4-azoethyl-β-naphthylamine: EtOH (478)
$C_{23}H_{24}ClN_5O$	Antipyrine-4-azoethyl-β-naphthylamine hydrochloride: EtOH (478)
$C_{23}H_{24}N_2O$	Tetramethyldiaminofuchsone (228)
$C_{23}H_{24}O$	Diphenylmethylenecamphor (560)
$C_{23}H_{24}O_5$	Tetramethoxytriphenylcarbinol: Me_2CO + acid (419.2)
$C_{23}H_{26}N_2O$	Camphorquinone phenylbenzylhydrazone (45)
$C_{23}H_{26}N_2O_4$	Brucine: EtOH (264)
$C_{23}H_{26}O$	Diphenylcamphomethane (560)
$C_{23}H_{27}NO_8$	Narceine (264); EtOH (140, 287, 605,‡ 606‡)
$C_{23}H_{36}O_2S_4$	Methylene fenchylxanthate (97)
$C_{24}H_{14}N_2O_5$	2-Nitro-6-anilino-1-hydroxynaphthacenequinone: EtOH, NaOEt, H_2SO_4, H_3BO_3 (41)
$C_{24}H_{15}NO_3$	1-Anilino-6-hydroxynaphthacenequinone: EtOH, NaOEt, H_2SO_4, H_3BO_3 (41)
$C_{24}H_{17}Cl_2N_3$	Phenylaminochlorophenazonium phenylchloride (16)
$C_{24}H_{18}N_4O_2$	Bis(benzeneazo)diphenol: EtOH (550)
$C_{24}H_{20}O_6$	Tribenzoin: EtOH (522)
$C_{24}H_{22}O_6$	Bis(anisylidenemethyl)pyrone formate: EtOH (76)
$C_{24}H_{26}O_6$	Pentamethoxytriphenylcarbinol: Me_2CO + acid (419.2)
$C_{24}H_{27}NOS_2$	1, 2-Diphenyl-3-fenchyl-imidoxanthogenide (97)
$C_{24}H_{30}OS_2$	Diphenylmethyl menthylxanthate: EtOH (97)
$C_{24}H_{35}ClN_2O_2$	Eucupinotoxine hydrochloride: *v.* p. 360
$C_{24}H_{36}Cl_2N_2O_2$	Eucupine dihydrochloride: *v.* p. 360
$C_{25}H_{24}N_4O$	2, 3-Bis(*p*-dimethylaminoanilo)-α-hydrindone: EtOH (516)
$C_{25}H_{27}NO_7$	Tetraacetylmorphine: EtOH (279)
$C_{25}H_{28}O_7$	2, 4, 2′, 4′, 2″, 4″-Hexamethoxytriphenylcarbinol (419.2)
$C_{25}H_{30}O_2$	Menthyl α(β)-phenylcinnamate (560)
$C_{25}H_{30}O_3$	Menthyl benzoylphenylacetate: C_6H_6 (559)
$C_{26}H_{19}NO$	Phthalophenone anilide (500)
$C_{26}H_{20}$	Tetraphenylethylene: $CHCl_3$ (393)
$C_{26}H_{20}O$	β-Benzopinacolin: $CHCl_3$ (392)
$C_{26}H_{22}$	Tetraphenylethane: $CHCl_3$ (393)
$C_{26}H_{22}N_4$	Benzilosazone (45)
$C_{26}H_{22}N_4O_2$	Bis(tolueneazo)diphenol: EtOH (550)
$C_{26}H_{24}N_2O_4S$	Benzylideneaniline sulfate (337)
$C_{26}H_{30}O_3$	Menthyl benzylidenebenzoylacetate: C_6H_6 (559)
$C_{27}H_{34}O_3$	Menthyl diphenylmethylacetoacetate: C_6H_6 (559)
$C_{28}H_{19}Cl_2N_3$	Naphthylaminochlorophenylphenazonium hydrochloride (16)
$C_{28}H_{28}AsI$	Tetrabenzylarsonium iodide: H_2O, $CHCl_3$ (242)
$C_{28}H_{24}O_2$	Menthyl α-styrylbenzoylacetate (559)

Formula	Name, solvents and literature
	Ultra-violet and Visible.—(*Continued*)
$C_{28}H_{36}N_2O_4$	Psychotrine (137)
$C_{28}H_{38}N_2O_4$	Cephaeline (137)
$C_{29}H_{40}N_2O_4$	Emetine (137)
$C_{30}H_{34}OS_2$	Triphenylmethyl menthylxanthate: EtOH (97)
$C_{30}H_{62}O$	Melissyl alcohol (438†)
$C_{32}H_{21}N_5O_4S_2$	Tetraphenyldithiopurpuric acid: MeOH (402)
$C_{32}H_{24}$	Tetraphenylquinonedimethane: EtOH, Et_2O (293)
$C_{32}H_{24}N_6O_6S_2$	Congo red (232); Na salt: acid, alk. (232)
$C_{32}H_{26}$	Tetraphenyl-*p*-xylene (410)
$C_{32}H_{49}NO_9$	Veratrine: EtOH (264)
$C_{33}H_{26}N_2O$	Benzoyldianilinostilbene: EtOH (155)
$C_{34}H_{24}Cl_2N_4$	Phenylaminonaphthylaminochlorophenazonium phenylchloride (16)
$C_{34}H_{25}ClN_4$	Phenylaminonaphthylaminophenazonium phenylchloride (16)
$C_{34}H_{39}ClN_4O_4$	Mesoporphyrin hydrochloride (433‡); EtOH (171‡); *cf.* p. 360
$C_{34}H_{47}NO_{11}$	Aconitine (264)
$C_{34}H_{48}N_2O_{10}S$	Atropine sulfate: H_2O (95‡); *cf.* p. 360
$C_{34}H_{48}N_2O_{10}S$	Hyosciamine sulfate: H_2O (95‡); *cf.* p. 360
$C_{35}H_{36}N_4O_5$	Phyllocyanine (433‡)
$C_{35}H_{56}O_{14}$	Digitalin: EtOH (264)
$C_{36}H_{40}N_4O_6$	Hematoporphyrin dimethyl ether (171‡); *cf.* p. 360
$C_{38}H_{30}$	Hexaphenylethane (13)
$C_{40}H_{26}$	Tetranaphthyl (323†)
$C_{40}H_{50}N_4O_8S$	Quinine sulfate: *v.* p. 360
$C_{40}H_{50}N_4O_8S$	Quinidine sulfate: *v.* p. 360
$C_{40}H_{54}N_4O_8S$	Hydroquinine sulfate: *v.* p. 360
$C_{40}H_{56}$	Carotin: Et_2O (131†)
$C_{40}H_{56}O_2$	Xanthophyllin: Et_2O (131†)
$C_{42}H_{54}N_4O_8S$	Methylquinine sulfate: *v.* p. 360
$C_{54}H_{92}N_2O_{18}$	Solanine: EtOH (264)

ORGANIC SUBSTANCES OF MIXED OR UNKNOWN COMPOSITION. NAME, SOLVENT AND LITERATURE REFERENCE

Albumin (265).
Albuminoids (129).
Allochlorophyllan: $CHCl_3$ (339).
Amino acids (129,† 357†)
Blood sera (381‡).
Cadaverine extract; *v.* p. 359
Casein (122,‡ 265†).
Chlorophyll (205,‡ 206‡); Et_2O (130†).
Chlorophyllan: $CHCl_3$ (339).
Hematine: acid, alk. (171‡); *cf.* p. 360
Hematoporphyrin (433‡).
Hematoporphyrin hydrochloride: EtOH, H_2O (171‡).
Hemin, α and β-bromo-derivatives: EtOH, H_2O (171‡), *cf.* p. 360
α-Hemin: EtOH, H_2O (171,‡ 433‡); *cf.* p. 360
Hemoglobin derivatives: H_2O (481‡).
Hemoglobin, reduced (258‡).
Hemoglobin, oxy- (129,† 258‡); H_2O (433,‡ 480,‡ 481‡).
Methemoglobin: $H_2O(+Na_2CO_3)$ (257†).
Neochlorophyllan: $CHCl_3$ (339)
Nucleic acid (122)
Nucleic acid deriv. (129†).
Petroleum, crude oils and products of refining (645.1‡).
Phycocyan: H_2O (625.5).
Phycoerythrin: H_2O (625.5).
Phylloerythrin (433‡).
Polypeptides (di- and tri-peptides) (357†).
Starch (from maize) (265†).

LITERATURE

(For a key to the periodicals see end of volume)

(1) Abney and Festing, *62*, **172**: 887; 81. (1.5) Acly and French, *1*, **49**: 847; 27. (2) Adinolfi, *22*, **29 II**: 38; 20. (3) Adinolfi, *22*, **29 II**: 87; 20. (4) Albuquerque, *Rev. chim. pura applicada*, **1**: 1916. (5) Anderson, *68*, **33**: 35; 13. (5.5) Anderson, *1*, **50**: 208; 28. (5.6) Anderson and Gomberg, *1*, **50**: 203; 28. (6) Ångström, *8*, **39**: 267; 90. (7) Ångström, *388*, **47**: 331; 90. (8) Ångström, *20*, **8**: 261; 13. (9) von Bahr, *8*, **29**: 780; 09.
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(20) Baly and Collie, *4*, **87**: 1332; 05. (21) Baly, Collie and Watson, *4*, **95**: 144; 09. (22) Baly and Desch, *4*, **85**: 1029; 04. (23) Baly and Desch, *4*, **87**: 756; 05. (24) Baly and Desch, *21*, **23**: 110; 06. (25) Baly and Desch, *4*, **93**: 1747; 08. (26) Baly, Edwards and Stewart, *4*, **89**: 514; 06. (27) Baly and Ewbank, *4*, **87**: 1347; 05. (28) Baly and Ewbank, *4*, **87**: 1355; 05. (29) Baly and Hampson, *4*, **107**: 248; 05.
(30) Baly and Marsden, *4*, **93**: 2108; 08. (31) Baly, Marsden and Stewart, *4*, **89**: 966; 06. (32) Baly and Rice, *4*, **101**: 1475; 12. (33) Baly and Rice, *4*, **103**: 91; 13. (34) Baly and Rice, *4*, **103**: 2085; 13. (35) Baly and Schaefer, *4*, **93**: 1808; 08. (36) Baly and Stewart, *4*, **89**: 502; 06. (37) Baly and Tryhorn, *4*, **107**: 1058; 15. (38) Baly and Tryhorn, *4*, **107**: 1121; 15. (39) Baly and Tryhorn, *3*, **31**: 417; 16.
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(50) von Beer, *8*, **86**: 78; 52. (51) Bell, *1*, **47**: 2192; 25. (52) Bell, *1*, **47**: 2811; 25. (52.1) Bell, *1*, **48**: 813; 26. (52.2) Bell, *1*, **48**: 818; 26. (52.3) Bell, *1*, **49**: 1837; 27. (52.4) Bennett and Daniels, *1*, **49**: 50; 27. (53) Bernard, *6*, **35**: 385; 52. (54) Bielecki and Henri, *34*, **155**: 456; 12. (55) Bielecki and Henri, *34*, **155**: 1617; 12. (56) Bielecki and Henri, *25*, **45**: 2819; 12. (57) Bielecki and Henri, *25*, **46**: 1304; 13. (58) Bielecki and Henri, *25*, **46**: 2596; 13. (59) Bielecki and Henri, *25*, **46**: 3627; 13.
(60) Bielecki and Henri, *34*, **156**: 550; 13. (61) Bielecki and Henri, *34*, **156**: 884; 13. (62) Bielecki and Henri, *34*, **156**: 1322; 13. (63) Bielecki and Henri, *34*, **156**: 1860; 13. (64) Bielecki and Henri, *34*, **157**: 372; 13. (65) Bielecki and Henri, *63*, **14**: 516; 13. (66) Bielecki and Henri, *25*, **47**: 1690; 14. (67) Bielecki and Henri, *34*, **158**: 567; 14. (68) Bielecki and Henri, *34*, **158**: 866; 14. (69) Bielecki and Henri, *34*, **158**: 1022; 14.
(70) Bielecki and Henri, *34*, **158**: 1114; 14. (71) Böeseken, Cohen and Langedijk, *70*, **44**: 173; 25. (72) Bonino, *36*, **53**: 555; 23. (73) Bonino, *36*, **53**: 575; 23. (74) Bonino, *36*, **53**: 8, 583; 23. (75) Bontempi, *550*, **29**: 209; 25. (76) Boon, Wilson and Heilbron, *4*, **105**: 2176; 14. (77) Bortini, *7*, **87**: 104; 14. (78) Bottomley, *398*, **7**: 66, 177; 82. *135*, **42**: 56; 80. (79) Boutaric and Vuillaume, *34*, **177**: 259; 23.
(80) Brady, *4*, **105**: 2104; 14 (81) Brannigan and Macbeth, *4*, **109**: 1277; 16. (82) Brannigan, Macbeth and Stewart, *4*, **103**: 406; 13. (83) Bredig and Goldberger, *7*, **110**: 521; 24. (83.2) Brode, *1*, **48**: 1877; 26. (83.3) Brode, *1*, **48**: 1984; 26. (83.4) Brode and Adams, *1*, **48**: 2193; 26. (83.5) Brode and Adams, *1*, **48**: 2202; 26. (84) Bruylants and Castille, *501*, **8**: No. 3; 25. (85) Burmeister, *88*, **15**: 589; 13. (86) Buttle and Hewitt, *4*, **95**: 1755; 09. (87) Byk, *7*, **61**: 1; 08. (88) Byk and Jaffe, *7*, **68**: 323; 10. (89) Cain, *25*, **46**: 101; 13.
(90) Cain, Macbeth and Stewart, *4*, **103**: 586; 13. (91) Callow, Lewis and Nodder, *4*, **109**: 55; 16. (92) Carr and Burt, *1*, **40**: 1590; 18. (93) Carr and Dobbrow, *1*, **47**: 2961; 25. (94) Carrelli, *71*, **27**: 274; 21. (95) Castille, *Bull. acad. roy. méd. belg.*, **5**: 193; 25. (96) Castille and Klingstedt, *34*, **176**: 749; 23. (97) Chugaev and Ogorodnikov, *7*, **85**: 481; 13. (98) Clarke and Stewart, *63*, **14**: 1049; 13. (99) Coblentz, *2*, **16**: 35; 03.
(100) Coblentz, *21*, **20**: 207; 04. (101) Coblentz, *152*, No. **35**; 05. (102) Coblentz, *152*, No. **65**; 06. (103) Coblentz, *152*, No. **97**; 08. (104) Coblentz, *31A*, **7**: 619; 11. (105) Coblentz, *31*, No. **418**; 21. (106) Coblentz, Emerson and Long, *31A*, **14**: 653; 19. (107) Collins, *2*, **20**: 486; 22. (108) Cooley, *2*, **21**: 376; 23. (109) Cooley, *21*, **62**: 73; 25.
(110) Cooper, *21*, **31**: 339; 10. (111) Cremer, *99*, **10**: 349; 12. (112) Crossley and Gilling, *4*, **97**: 518; 10. (113) Crymble, *4*, **105**: 658; 14. (114) Crymble, *4*, **101**: 266; 12. (115) Crymble, Ross and Smiles, *4*, **101**: 1146; 12. (116) Crymble, Stewart and Wright, *25*, **43**: 1183; 10. (117) Crymble, Stewart and Wright, *25*, **43**: 1188; 10. (118) Crymble, Stewart and Wright,

25, **43**: 1191; 10. (119) Crymble, Stewart, Wright and Glendenning, *4*, **99**: 451; 11.
(120) Crymble, Stewart, Wright and Rea, *4*, **99**: 1262; 11. (121) Cumming and Steel, *4*, **123**: 2464; 23. (122) Damianovich and Williams, *550*, **98**: 241; 24. (123) Delépine and Compin, *27*, **27**: 474; 20. (124) Deslandres, *34*, **169**: 1365; 19. (125) Deslandres, *34*, **180**: 1454; 1980; 25. (126) Deslandres, *34*, **181**: 387; 25. (127) Dhéré, *34*, **141**: 719; 05. (128) Dhéré, *27*, **1**: 834; 07. (129) Dhéré, *Diss.*, Freiburg, 1909.
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(140) Dobbie and Lauder, *4*, **83**: 605; 03. (141) Dobbie and Lauder, *4*, **83**: 626; 03. (142) Dobbie and Lauder, *4*, **99**: 34; 11. (143) Dobbie and Lauder, *4*, **99**: 1254; 11. (144) Dobbie, Lauder and Tinkler, *4*, **83**: 598; 03. (145) Dobbie and Tinkler, *4*, **85**: 1005; 04. (146) Dobbie and Tinkler, *4*, **87**: 269; 05. (147) Dobbie and Tinkler, *4*, **87**: 273; 05. (148) Donath, *8*, **58**: 609; 96. (148.5) Dorcas and Forbes, *1*, **49**: 3081; 27. (149) Dreisch, *96*, **30**: 200; 24.
(150) Durrans, *517*, **12**: 370; 21. (151) Ellis, *2*, **19**: 546; 22. (152) Ellis, *2*, **22**: 200; 23. **23**: 48; 24. (153) Ellis, *48*, **8**: 1; 24. (153.2) Ellis, *1*, **49**: 347; 27. (153.3) Ellis, *1*, **50**: 685; 28. (154) Errera and Henri, *34*, **180**: 2049; 25. (155) Everest and McCombie, *4*, **99**: 1752; 11. (156) Fischer and Steiner, *34*, **175**: 882; 22. (157) Forster, *4*, **89**: 222; 06. (158) Fox, *4*, **97**: 1119; 10. (159) Fox, *4*, **97**: 1337; 10.
(160) Fox and Pope, *4*, **101**: 1498; 12. (161) Fox and Pope, *4*, **103**: 1263; 13. (162) Franchimont and Backer, *4*, **101**: 2256; 12. (163) Franchimont and Backer, *70*, **32**: 158; 13. (164) Franchimont and Backer, *70*, **32**: 321; 13. (165) Franchimont and Backer, *70*, **32**: 325; 13. (166) Franz, *8*, **94**: 337; 55. (167) French, *Thesis*, Zürich, 1914. (168) French and Lowry, *5*, **106**: 489; 24. (169) Friedel, *8*, **55**: 453; 95.
(170) Friederichs, *99*, **3**: 154; 05. (171) Friedli, *Bull. soc. chim. biol.*, **6**: 908; 24. (172) Fryer and Fryer, *173*, **44**: 363; 19. (173) Garnier, *149*, **40**: 93; 15. (174) Garrett, *4*, **107**: 1324; 15. (174.2) Gebauer-Fülnegg, *1*, **49**: 2270; 27. (175) Gelbke, *63*, **13**: 584; 11. (176) Gelbke, *200*, **10**: 1; 13. (176.2) Gerke, *1*, **49**: 2671; 27. (177) Getman, *50*, **25**: 147; 21. (178) Getman, *50*, **26**: 217; 22. (179) Getman, *50*, **26**: 377; 22.
(180) Getman, *50*, **28**: 397; 24. (181) Getman, *50*, **29**: 853; 25. (181.5) Getman, *50*, **30**: 266; 26. (182) Ghosh and Bisvas, *9*, **30**: 97; 24. (183) Ghosh and Watson, *4*, **111**: 815; 17. (184) Gibbs, Howe and Tyndall, *2*, **10**: 779; 17. (185) Gibbs and Pratt, *267*, **7**: 371; 13. (186) Gibson, *348*, **4**: No. 5, 53; 20. (187) Gibson and Argo, *2*, **7**: 33; 16. (188) Gibson and Argo, *1*, **40**: 1327; 18. (189) Gibson, Graham and Reid, *4*, **123**: 874; 23.
(190) Gibson, Simonsen and Rau, *4*, **111**: 69; 17. (191) Glatzel, *63*, **1**: 173, 285; 00. (192) Glocker, *197*, **11**: 74; 25. (193) Gombos, *205*, **151**: 1; 24. (194) Gompel and Henri, *34*, **156**: 1541; 13. (195) Gompel and Henri, *34*, **157**: 1422; 13. (196) Gorke, Köppe and Staiger, *25*, **41**: 1156; 08. (197) Graham, *11*, **48**: 145; 12. (198) Graham and Macbeth, *4*, **121**: 1109; 22. (199) Graham and Macbeth, *4*, **121**: 2601; 22.
(200) Grantham, *2*, **18**: 339; 21. (201) Grandmougin and Favre-Ambrumyan, *25*, **47**: 2127; 14. (202) Grebe, *99*, **3**: 376; 05. (203) Grebe, *99*, **9**: 130; 10. (204) Grossman, *7*, **109**: 305; 24. (205) van Gulik, *8*, **23**: 277; 07. (206) van Gulik, *8*, **46**: 147; 15. (207) Guy, Shaeffer and Jones, *63*, **14**: 278; 13. (208) Hagenbach and Percy, *37*, **5**: 454; 22. (209) von Halban and Ebert, *7*, **112**: 321; 24.
(210) von Halban and Geigel, *7*, **96**: 214; 20. (211) von Halban and Hecht, *9*, **24**: 65; 18. (212) von Halban, Mackert and Ott, *9*, **29**: 445; 23. (213) von Halban and Seidentopf, *7*, **100**: 208; 22. (214) Haller and Lucas, *34*, **176**: 45; 23. (215) Hantzsch, *25*, **42**: 68; 09. (216) Hantzsch, *25*, **42**: 2129; 09. (217) Hantzsch, *25*, **43**: 1651; 10. (218) Hantzsch, *25*, **43**: 1662; 10. (219) Hantzsch, *25*, **43**: 2512; 10.
(220) Hantzsch, *25*, **43**: 3049; 10. (221) Hantzsch, *7*, **72**: 362; 10. (222) Hantzsch, *25*, **44**: 1771; 11. (223) Hantzsch, *25*, **44**: 1783; 11. (224) Hantzsch, *13*, **384**: 135; 11. (225) Hantzsch, *25*, **45**: 553; 12. (226) Hantzsch, *25*, **45**: 559; 12. (227) Hantzsch and Shibata, *93*, **73**: 309; 12. (228) Hantzsch, *9*, **18**: 470; 12. (229) Hantzsch, *25*, **46**: 1537; 13.
(230) Hantzsch, *7*, **84**: 321; 13. (231) Hantzsch, *7*, **96**: 624; 14. (232) Hantzsch, *25*, **48**: 158; 15. (233) Hantzsch, *25*, **48**: 167; 15. (234) Hantzsch, *25*, **49**: 511; 15. (235) Hantzsch, *25*, **48**: 772; 15. (236) Hantzsch, *25*, **48**: 797; 15. (237) Hantzsch, *25*, **48**: 1407; 15. (238) Hantzsch, *25*, **49**: 226; 16. (239) Hantzsch, *25*, **50**: 1413; 17.
(240) Hantzsch, *25*, **50**: 1422; 17. (241) Hantzsch, *25*, **52**: 1535; 19. (242) Hantzsch, *25*, **52**: 1544; 19. (243) Hantzsch and Heilbron, *25*, **43**: 68; 10. (244) Hantzsch and Hein, *25*, **52**: 493; 19. (245) Hantzsch and Kanasirski, *25*, **42**: 889; 09. (246) Hantzsch and Korczynski, *25*, **42**: 1216; 09. (247) Hantzsch and Lifschitz, *25*, **45**: 3011; 12. (248) Hantzsch and Lister, *25*, **43**: 1685; 10. (249) Hantzsch and Picton, *25*, **42**: 2119; 09.
(250) Hantzsch and Robertson, *25*, **43**: 106; 10. (251) Hantzsch and Robison, *25*, **43**: 45; 10. (252) Hantzsch and Scharf, *25*, **46**: 3570; 13. (253) Hantzsch and Schwiete, *25*, **49**: 213; 16. (254) Hantzsch and Staiger, *25*, **41**: 1204; 08. (255) Hantzsch and Voigt, *25*, **45**: 85; 12. (256) Hantzsch and Voigt, *7*, **79**: 592; 12. (257) Hari, *205*, **103**: 271; **20**. (258) Hari, *205*, **115**: 52; 21. (259) Harper and Macbeth, *4*, **107**: 87; 15.
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(270) Hartley, *4*, **93**: 961; 08. (271) Hartley, *62*, **208**: 475; 08. (272) Hartley, *4*, **101**: 820; 12. (273) Hartley and Dobbie, *4*, **73**: 598; 98. (274) Hartley and Dobbie, *4*, **73**: 695; 98. (275) Hartley and Dobbie, *4*, **75**: 640; 99. (276) Hartley and Dobbie, *4*, **77**: 318; 00. (277) Hartley and Dobbie, *4*, **77**: 498; 00. (278) Hartley and Dobbie, *4*, **77**: 509; 00. (279) Hartley and Dobbie, *4*, **77**: 846; 00.
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(290) Hedley, *4*, **89**: 730; 06. (291) Hedley, *25*, **41**: 1195; 08. (292) Heilbron, Barnes and Morton, *4*, **123**: 2559; 23. (293) Heilbron and Henderson, *4*, **103**: 1404; 13. (294) Henderson, Henderson and Heilbron, *25*, **47**: 876; 14. (295) Heilbron and Wilson, *4*, **101**: 1482; 12. (296) Heilbron and Wilson, *4*, **103**: 1504; 13. (297) Henri, *Études de photochimie*. Paris, Gauthier-Villars, 1919. (298) Henri, *25*, **46**: 3650; 13. (299) Henri, *Résumé des communications, soc. franç. phys.*, **1921**: 19. *10*, **5**: 665; 25.
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(320) Hill and Howell, *3*, **48**: 833; 24. (321) Hoffmann and Höschele, *25*, **47**: 238; 14. (322) Holmberg, *93*, **71**: 226; 11. (322.5) Holton and Hopkins, *1*, **50**: 255; 28. (323) Homer and Purvis, *4*, **93**: 1319; 08. (324) Homer and Purvis, *4*, **97**: 280; 10. (325) Homer and Purvis, *4*, **97**: 1155; 10. (326) Houston, *68*, **31**: 521; 11. (327) Houston, *68*, **31**: 538; 11. (328) Houston, *68*, **31**: 547; 11. (329) Houston, *68*, **32**: 40; 12.
(330) Houston and Brown, *68*, **31**: 530; 11. (331) Houston and Cochrane, *68*, **33**: 147; 13. (332) Houston and Gray, *68*, **33**: 137; 13. (333) Howe and Gibson, *2*, **10**: 767; 17. (334) Hutchinson and Smiles, *25*, **47**: 514; 14. (335) Hyatt, *2*, **19**: 391; 22. (336) Ikle, *63*, **5**: 271; 04. (337) Izmailski, *53*, **50**: 167; 18. (338) Izmailski, *53*, **52**: 303; 20. (339) Jacobson and Marchlewski, *11*, **48**: 111; 12.
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QUANTITATIVE DETERMINATION OF ULTRA-VIOLET ABSORPTION SPECTRA IN SOLUTIONS OF ORGANIC SUBSTANCES

VICTOR HENRI

NOMENCLATURE

J_0 (resp. J) Intensity of the incident (resp. emergent) ray.

λ (resp. λ_0) Wave-length of the light in the medium (resp. *in vacuo*). $\lambda/\lambda_0 = 1/n_\lambda$.

l Length of path in the medium.

(1) $J = J_0 e^{-\mu l}$ μ is the absorption coefficient.

(2) $J = J_0 r^l$ r is the transmission coefficient.

(3) $J = J_0 10^{-Kl}$ K is the extinction coefficient.

(4) $J = J_0 10^{-\epsilon c l}$ ϵ is the molecular extinction coefficient.

(5) $J = J_0 e^{\frac{-4\pi\kappa l}{\lambda}}$ κ is the absorption index.

The above coefficients are connected by the following relations:

$$\mu = 2.3026\epsilon c$$
$$-\log_{10} r = \epsilon c$$
$$\kappa = 0.7956\ \mu\lambda \cdot (\lambda \text{ in cm})$$
$$\kappa = 1.832\ \epsilon c\lambda \cdot (\lambda \text{ in cm})$$

ϵ	$\log_{10}\epsilon$	μ	κ/λ	r	d
0.01	−2	0.023026	0.01832	0.9773	100 cm
0.1	−1	0.23026	0.1832	0.7943	10 cm
1	0	2.3026	1.832	0.1	1 cm
10	+1	23.026	18.32	10^{-10}	0.1 cm
100	+2	230.26	183.2	10^{-100}	0.01 cm
1 000	+3	2 302.6	1 832	$10^{-1\,000}$	0.001 cm
10 000	+4	23 026	18 320	$10^{-10\,000}$	0.0001 cm
100 000	+5	230 260	183 200	$10^{-100\,000}$	0.00001 cm

In the above table d represents for a normal solution ($c = 1$) the path length in which 90% of the incident light is absorbed. It is called the "active region" ("l'épaisseur active") since it represents the layer within which photochemical reactions occur.

DESCRIPTION OF FIGURES

The figures are drawn to the same scale to facilitate comparison. They are based upon the best data recorded in the literature and many of them have been checked in the author's laboratory.

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C_4H_6O, Crotonaldehyde; Fig. 73
$C_4H_6O_2$, Diacetyl; Fig. 85
$C_4H_6O_2$, α-Crotonic acid; Figs. 77, 84
$C_4H_6O_4$, Succinic acid; Fig. 77
$C_4H_7NO_3$, Acetylglycine; Fig. 35
$C_4H_7NO_4$, Aspartic acid; Fig. 71
$C_4H_8N_2O_3$, Asparagine; Fig. 71
C_4H_8O, Isobutyraldehyde; Fig. 31
$C_4H_9N_3O_2$, Creatine; Fig. 35
$C_4H_{14}Cl_2N_2$, Putresceine hydrochloride; Fig. 55
$C_5H_4N_4O_3$, Uric acid; Figs. 38, 45
$C_5H_4O_2$, Furfuraldehyde; Fig. 91
$C_5H_4O_3$, Furan-α-carboxylic acid (Pyromucic acid); Fig. 91
C_5H_5N, Pyridine; Figs. 21, 33, 47
C_5H_6, Cyclopentadiene; Fig. 20
$C_5H_6O_2$, Furfuralcohol; Fig. 91
C_5H_8, Isoprene; Fig. 25
$C_5H_8O_2$, Acetylacetone; Figs. 57, 61, 85
$C_5H_8O_3$, Levulinic acid; Fig. 81
$C_5H_9NO_4$, Glutamic acid; Fig. 71
C_5H_{10}, Trimethylethylene; Fig. 25
$C_5H_{12}BrN$, Neurine hydrobromide; Fig. 34
$C_5H_{12}ClNO_2$, Betaine hydrochloride; Fig. 34
$C_5H_{14}ClNO$, Choline hydrochloride; Fig. 34
$C_5H_{14}N_2$, Cadaverine extract; Figs. 41, 42
$C_5H_{16}Cl_2N_2$, Cadaverine hydrochloride; Fig. 55
$C_6H_4O_2$, Paraquinone; Figs. 86, 87
$C_6H_5NO_2$, Nicotinic acid; Fig. 47
$C_6H_5N_3$, Phenylazide (Triazobenzene); Fig. 69
C_6H_6, Benzene; Figs. 1, 4, 10, 21, 26, 27, 33, 39, 58, 63, 67, 78, 79, 89
C_6H_6O, Phenol; Figs. 5, 6, 8, 72, 79
$C_6H_6O_2$, Hydroquinol; Figs. 5, 79, 86
$C_6H_6O_2$, Pyrocatechol; Figs. 5, 7
$C_6H_6O_2$, Resorcinol; Fig. 7
$C_6H_6O_6$, Aconitic acid; Fig. 77
C_6H_7N, Aniline; Figs. 3, 10, 58, 80
$C_6H_8O_6$, Tricarballylic acid; Fig. 77
$C_6H_9N_3O_2$, Histidine; Fig. 71
C_6H_{10}, Diallyl; Fig. 25
C_6H_{10}, Dimethylbutadiene; Fig. 25

$C_6H_{10}O$, Mesityl oxide; Figs. 68, 74
$C_6H_{10}O$, Diethylketene; Fig. 82
$C_6H_{10}O_2$, Methylacetylacetone; Fig. 61
$C_6H_{10}O_2$, Ethyl crotonate; Fig. 44
$C_6H_{10}O_2$, Acetonylacetone; Figs. 81, 85
$C_6H_{10}O_3$, Ethyl acetoacetate; Figs. 44, 62
$C_6H_{11}BrN_2O_2$, Bromural; Fig. 37
$C_6H_{12}O$, Methyl isobutyl ketone; Fig. 68
$C_6H_{12}O_3$, Paraldehyde; Fig. 30
$C_6H_{13}NO_2$, Leucine; Fig. 71
$C_6H_{14}N_2O_2$, Lysine; Fig. 55
$C_6H_{14}N_4O_2$, Arginine; Fig. 71
$C_7H_5NO_4$, Quinolinic acid; Fig. 47
$C_7H_6N_2$, Phenyldiazomethane; Fig. 94
C_7H_6O, Benzaldehyde; Figs. 67, 88
$C_7H_6O_2$, Benzoic acid; Figs. 13, 27, 35, 39, 40, 63, 72
$C_7H_6O_2$, Toluquinone; Fig. 87
$C_7H_6O_3$, *o*, *m*, *p*-Hydroxybenzoic acids; Fig. 13: *o*-(Salicylic acid); Fig. 72
C_7H_8, Toluene; Fig. 1
$C_7H_8N_4O_2$, Theobromine; Fig. 45
$C_7H_8N_4O_2$, Theophylline; Fig. 45
C_7H_8O, *o*, *p*-Cresols; Figs. 8, 9: *m*-; Fig. 9
C_7H_9N, *o*, *m*, *p*-Toluidine; Figs. 11, 12: *p*-; Figs. 3, 10
$C_7H_{10}N_2O_4$, Diethyl diazomalonate; Fig. 94
$C_7H_{12}O$, Suberone; Fig. 46
$C_7H_{12}O_6$, Quinic acid; Fig. 49
$C_7H_{13}BrN_2O_2$, Adaline; Fig. 37
C_8H_7N, Indole; Figs. 26, 33, 56, 72
$C_8H_8O_2$, Phenylacetic acid; Fig. 39
$C_8H_8O_3$, Vanillin; Fig. 67
$C_8H_8O_5$, Hematinic acid anhydride; Fig. 70
$C_8H_9NO_4$, Hematinic acid imide; Fig. 70
C_8H_{10}, *o*-, *m*-, *p*-Xylene; Figs. 2, 4: *p*-; Fig. 1
$C_8H_{10}N_4O_2$, Caffeine; Fig. 45
$C_8H_{10}O_2$, *o*-Veratrole; Fig. 67
$C_8H_{12}N_2O_3$, Veronal; Fig. 36
$C_8H_{13}NO$, Tropinone; Fig. 46
$C_8H_{14}O$, Methylheptenone; Fig. 74
$C_8H_{14}O_3$, Ethyl β-ethoxycrotonate; Fig. 44
$C_8H_{15}NO$, Tropine; Fig. 46
C_9H_7N, Isoquinoline; Fig. 21
C_9H_7N, Quinoline; Figs. 21, 26, 48, 49, 56, 60, 65, 66
$C_9H_8O_2$, Cinnamic acid; Fig. 39
$C_9H_9NO_3$, Hippuric acid; Fig. 35
$C_9H_{10}O_2$, Phenylpropionic acid; Fig. 39
$C_9H_{10}O_3$, Tropic acid; Figs. 27, 39
$C_9H_{11}NO_2$, Phenylalanine; Fig. 72
$C_9H_{11}NO_3$, Tyrosine; Fig. 72
$C_9H_{14}O$, Phorone; Fig. 74
$C_9H_{15}NO_3$, Ecgonine; Fig. 46
$C_{10}H_7Br$, $\alpha(\beta)$-Bromonaphthalene; Fig. 16
$C_{10}H_7NO_2$, Cinchoninic acid; Figs. 49, 50
$C_{10}H_8$, Naphthalene; Figs. 21, 78, 89
$C_{10}H_8O$, $\alpha(\beta)$-Naphthol; Fig. 17
$C_{10}H_9N$, $\alpha(\beta)$-Naphthylamine; Fig. 22
$C_{10}H_9NO$, *p*-Methoxyquinoline; Fig. 48
$C_{10}H_{16}O$, Citral; Fig. 74
$C_{10}H_{18}O_3$, Ethyl diethylacetoacetate; Fig. 44
$C_{11}H_7N$, $\alpha(\beta)$-Naphthonitrile; Fig. 19
$C_{11}H_8O_2$, $\alpha(\beta)$-Naphthoic acid; Fig. 18
$C_{11}H_9NO_3$, Quininic acid; Fig. 49
$C_{11}H_{10}$, $\alpha(\beta)$-Methylnaphthalene; Fig. 14
$C_{11}H_{12}N_2O_2$, Tryptophane; Figs. 41, 72
$C_{11}H_{14}N_2O$, Cytisine; Fig. 66
$C_{12}H_9N$, Carbazole; Fig. 80
$C_{12}H_{10}$, Diphenyl; Figs. 78, 90
$C_{12}H_{10}N_2$, Azobenzene; Fig. 80
$C_{12}H_{11}N$, Diphenylamine; Fig. 80
$C_{12}H_{12}$, 2, 6(2, 7)-Dimethylnaphthalene; Fig. 15
$C_{12}H_{12}N_2O_3$, Luminal; Fig. 36
$C_{12}H_{13}N$, $\alpha(\beta)$-Dimethylnaphthylamine; Fig. 23
$C_{13}H_{10}$, Fluorene; Fig. 89
$C_{13}H_{10}N_2$, Diphenyldiazomethane; Fig. 94
$C_{13}H_{10}O$, Benzophenone; Fig. 88
$C_{13}H_{12}$, Diphenylmethane; Fig. 89
$C_{14}H_{10}O_2$, Dibenzoyl (Benzil); Fig. 88
$C_{14}H_{12}$, 1, 1-Diphenylethylene; Fig. 90
$C_{14}H_{12}$, Stilbene; Fig. 90
$C_{14}H_{12}O_2$, Benzoin; Fig. 88
$C_{14}H_{14}$, Dibenzyl; Fig. 89
$C_{16}H_{13}N$, $\alpha(\beta)$-Phenylnaphthylamine; Fig. 23
$C_{16}H_{14}$, Diphenylbutadiene; Fig. 90
$C_{16}H_{19}NO_4$, Benzoylecgonine; Figs. 27, 40, 63
$C_{16}H_{21}NO_3$, Homoatropine; Fig. 40
$C_{17}H_{22}ClNO_4$, Cocaine hydrochloride; Figs. 27, 40, 41
$C_{19}H_{22}N_2O$, Cinchotoxine; Fig. 50
$C_{19}H_{22}N_2O$, Cinchonine; Figs. 28, 50, 65
$C_{19}H_{22}N_2O_2.2H_2O$, Apoquinine; Figs. 53, 54
$C_{19}H_{22}N_2O_4$, Quitenine; Fig. 64
$C_{19}H_{23}ClN_2O$, Cinchonine hydrochloride; Fig. 28
$C_{19}H_{24}N_2O_2$, Hydrocupreine; Fig. 53
$C_{20}H_{22}N_2O_2$, Hydroquininone; Fig. 95
$C_{20}H_{24}N_2O_2$, α-Isoquinine; Fig. 52
$C_{20}H_{24}N_2O_2$, Quinine; Figs. 51, 65
$C_{20}H_{24}N_2O_2$, Chinotoxine; Figs. 52, 95
$C_{20}H_{25}ClN_2O_2$, Quinine hydrochloride; Figs. 51, 64
$C_{20}H_{26}N_2O_2$, Hydrochinotoxine; Fig. 95
$C_{21}H_{26}N_2O_3$, Yohimbine; Fig. 56
$C_{21}H_{28}N_2O_2$, Optoquinine; Fig. 54
$C_{24}H_{36}Cl_2N_2O_2$, Eucupine dihydrochloride; Figs. 54, 64
$C_{24}H_{35}ClN_2O_2$, Eucupinotoxine hydrochloride; Fig. 54
$C_{34}H_{32}BrFeN_4O_4$, $\alpha(\beta)$-Bromohemin; Fig. 92
$C_{34}H_{32}ClFeN_4O_4$, α-Hemin; Fig. 92
$C_{34}H_{33}FeN_4O_5$, Hematine; Fig. 75
$C_{34}H_{39}ClN_4O_4$, Mesoporphyrin hydrochloride; Fig. 75
$C_{34}H_{48}N_2O_{10}S$, Atropine sulfate; Fig. 40
$C_{34}H_{48}N_2O_{10}S$, Hyosciamine sulfate; Fig. 40
$C_{36}H_{40}N_4O_6$, Hematoporphyrin dimethyl ether; Fig. 75
$C_{40}H_{50}N_4O_8S$, Quinine sulfate; Figs. 51, 52, 53, 54, 60, 65, 95
$C_{40}H_{50}N_4O_8S$, Quinidine sulfate; Fig. 52
$C_{40}H_{54}N_4O_8S$, Hydroquinine sulfate; Figs. 53, 64
$C_{42}H_{54}N_4O_8S$, Methylquinine sulfate; Fig. 64

LITERATURE

(For a key to the periodicals see end of volume)

(1) Bielecki and Henri, *25*, **46**: 2596; 13. (2) Bielecki and Henri, *34*, **158**: 567; 14. (3) Bielecki and Henri, *25*, **46**: 3627; 13. **47**: 1690; 14. (4) Castille, *Bull. acad. roy. med. belg.*, **5**: 193; 25. (5) Castille, *186*, **12**: 498; 26. (6) Castille, *28*, **36**: 292; 27. (7) Castille and Klingstedt, *34*, **176**: 749; 23. (8) Errera, *51*, **7**: 215; 26. (9) Fischer, *Die physikalische Chemie in der gerichtlichen Medizin und der Toxikologie*. Zürich, Institut d. Univ. Zürich, 1925. (10) Friedli, *Bull. soc. chim. biol.*, **6**: 908; 24. (11) Grossman, *7*, **109**: 305; 24. (12) Henri, *Études de photochimie*. Paris, Gauthier-Villars, 1919. (13) Klingstedt, *34*, **174**: 812; 22. (14) Klingstedt, *34*, **175**: 365; 22. (15) Klingstedt, *34*, **175**: 1065; 22. (16) Klingstedt, *34*, **176**: 248; 23. (17) Klingstedt, *34*, **176**: 674; 23. (18) Klingstedt, *34*, **176**: 1550; 23. (19) Klingstedt, *554*, **3**: No. 5; 24. (20) Lardy, *42*, **21**: 353; 24. (21) de László, *34*, **180**: 203; 25. (22) de László, *5*, **111**: 355; 26. (23) Light, *7*, **122**: 414; 26. (24) Lüthy, *7*, **107**: 285; 23. (25) Lüthy, *34*, **176**: 1547; 23. (26) Lüthy, *7*, **107**: 285; 23. (27) Menczel, *7*, **125**: 161; 27. (28) Schou, *34*, **182**: 965; 26. (29) Schou, *34*, **184**: 1452; 27. (30) Steiner, *34*, **176**: 744; 23.

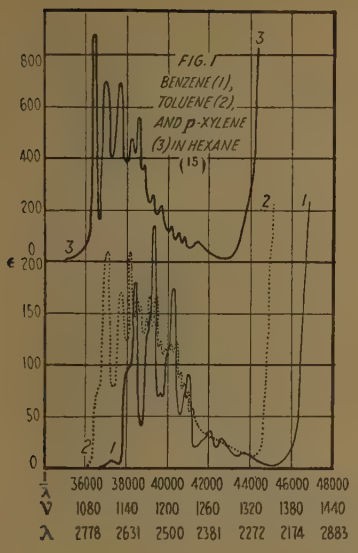


FIG. 1
BENZENE (1), TOLUENE (2), AND p-XYLENE (3) IN HEXANE
(15)
ε
1/λ 36000 38000 40000 42000 44000 46000 48000
ν̄ 1080 1140 1200 1260 1320 1380 1440
λ 2778 2631 2500 2381 2272 2174 2083

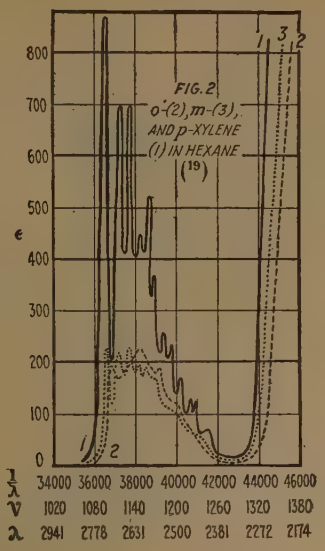


FIG. 2
o-(2), m-(3), AND p-XYLENE (1) IN HEXANE
(19)
ε
1/λ 34000 36000 38000 40000 42000 44000 46000
ν̄ 1020 1080 1140 1200 1260 1320 1380
λ 2941 2778 2631 2500 2381 2272 2174

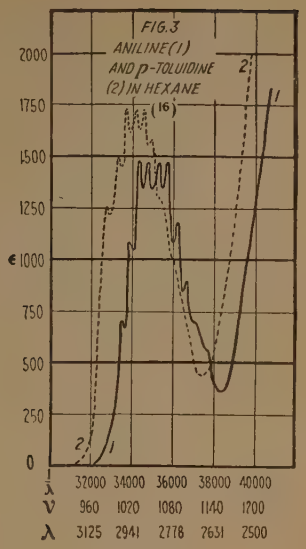


FIG. 3
ANILINE (1) AND p-TOLUIDINE (2) IN HEXANE
(16)
ε
1/λ 32000 34000 36000 38000 40000
ν̄ 960 1020 1080 1140 1200
λ 3125 2941 2778 2631 2500

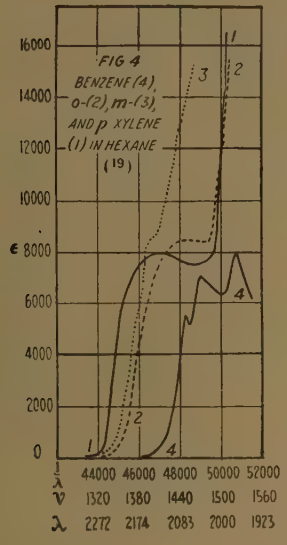


FIG 4
BENZENE (4), o-(2), m-(3), AND p XYLENE (1) IN HEXANE
(19)
ε
1/λ 44000 46000 48000 50000 52000
ν̄ 1320 1380 1440 1500 1560
λ 2272 2174 2083 2000 1923

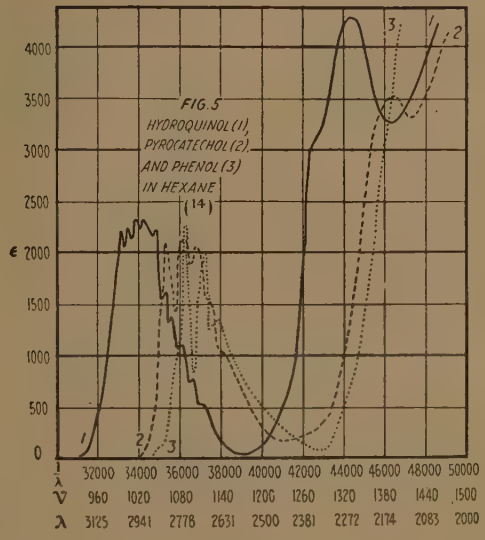


FIG. 5
HYDROQUINOL (1), PYROCATECHOL (2), AND PHENOL (3) IN HEXANE
(14)
ε
1/λ 32000 34000 36000 38000 40000 42000 44000 46000 48000 50000
ν̄ 960 1020 1080 1140 1200 1260 1320 1380 1440 1500
λ 3125 2941 2778 2631 2500 2381 2272 2174 2083 2000

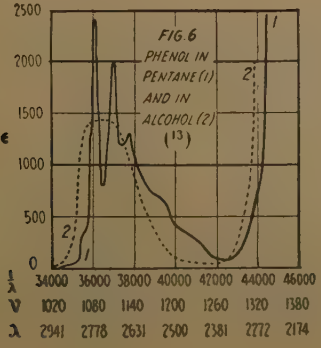


FIG. 6
PHENOL IN PENTANE (1) AND IN ALCOHOL (2)
(13)
ε
1/λ 34000 36000 38000 40000 42000 44000 46000
ν̄ 1020 1080 1140 1200 1260 1320 1380
λ 2941 2778 2631 2500 2381 2272 2174

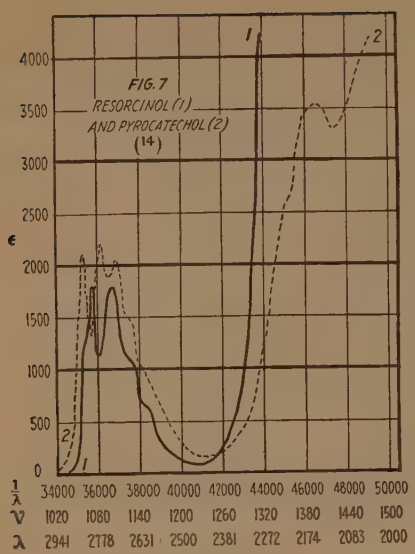


FIG. 7
RESORCINOL (1) AND PYROCATECHOL (2) (14)
ε
1/λ 34000 36000 38000 40000 42000 44000 46000 48000 50000
ν 1020 1080 1140 1200 1260 1320 1380 1440 1500
λ 2941 2778 2631 2500 2381 2272 2174 2083 2000

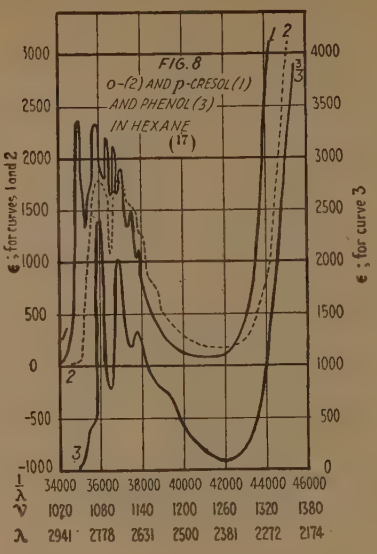


FIG. 8
o-(2) AND p-CRESOL (1) AND PHENOL (3) IN HEXANE (17)
ε; for curves 1 and 2
ε; for curve 3
1/λ 34000 36000 38000 40000 42000 44000 46000
ν 1020 1080 1140 1200 1260 1320 1380
λ 2941 2778 2631 2500 2381 2272 2174

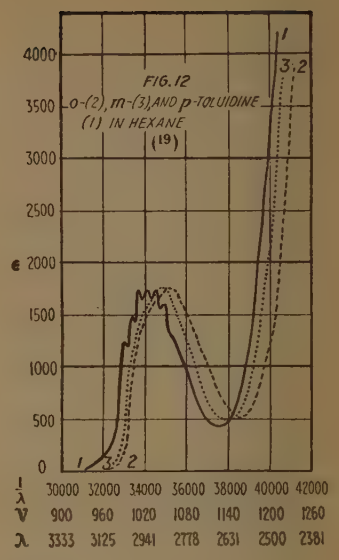


FIG. 12
o-(2), m-(3), AND p-TOLUIDINE (1) IN HEXANE (19)
ε
1/λ 30000 32000 34000 36000 38000 40000 42000
ν 900 960 1020 1080 1140 1200 1260
λ 3333 3125 2941 2778 2631 2500 2381

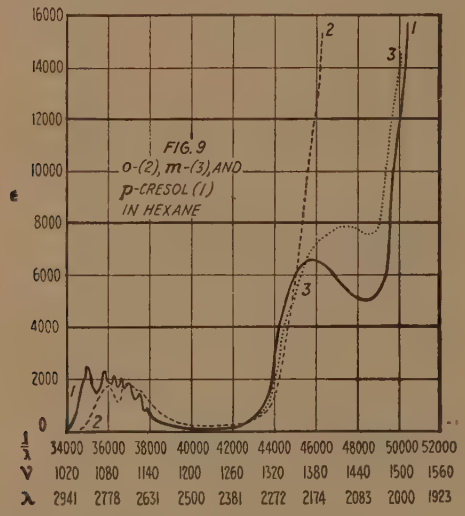


FIG. 9
o-(2), m-(3), AND p-CRESOL (1) IN HEXANE
ε
1/λ 34000 36000 38000 40000 42000 44000 46000 48000 50000 52000
ν 1020 1080 1140 1200 1260 1320 1380 1440 1500 1560
λ 2941 2778 2631 2500 2381 2272 2174 2083 2000 1923

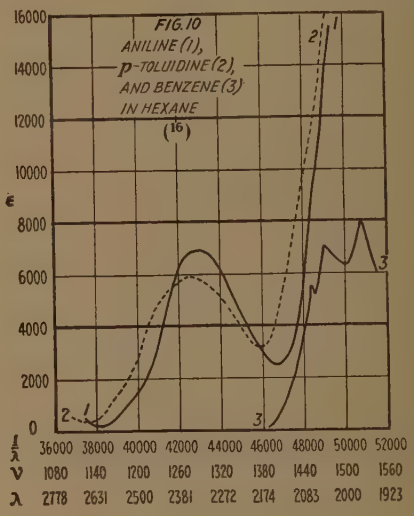


FIG. 10
ANILINE (1), p-TOLUIDINE (2), AND BENZENE (3) IN HEXANE (16)
ε
1/λ 36000 38000 40000 42000 44000 46000 48000 50000 52000
ν 1080 1140 1200 1260 1320 1380 1440 1500 1560
λ 2778 2631 2500 2381 2272 2174 2083 2000 1923

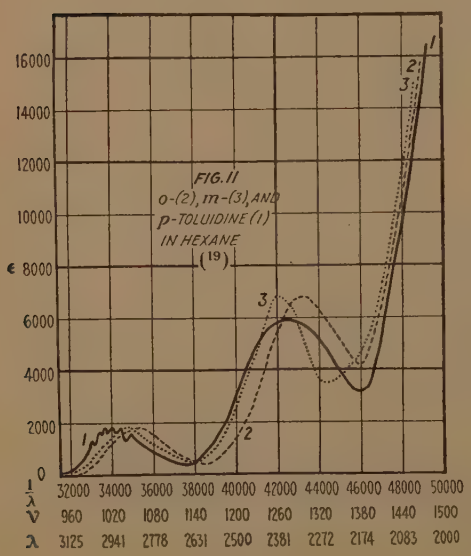


FIG. 11
o-(2), m-(3), AND p-TOLUIDINE (1) IN HEXANE (19)
ε
1/λ 32000 34000 36000 38000 40000 42000 44000 46000 48000 50000
ν 960 1020 1080 1140 1200 1260 1320 1380 1440 1500
λ 3125 2941 2778 2631 2500 2381 2272 2174 2083 2000

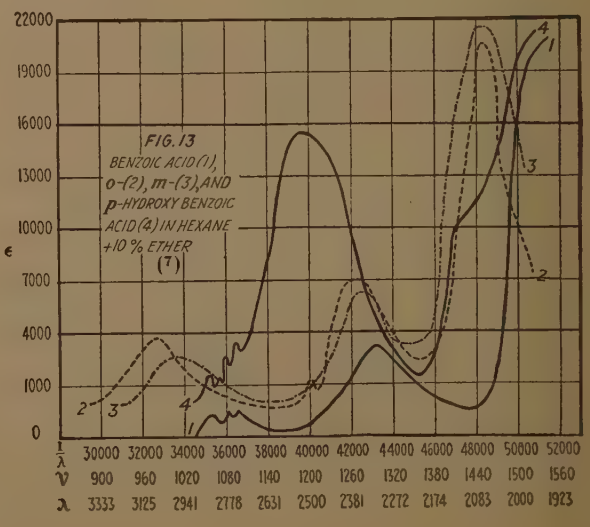
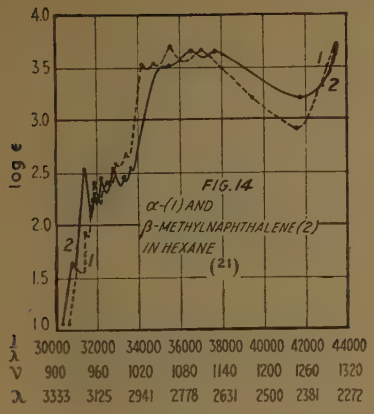
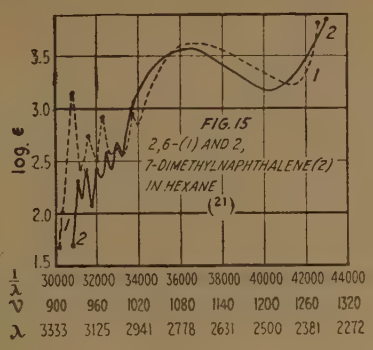
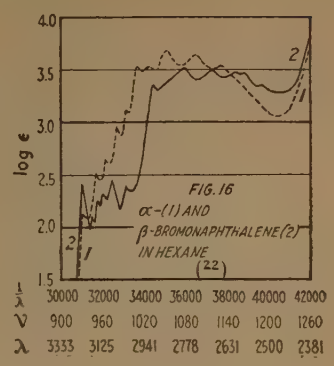
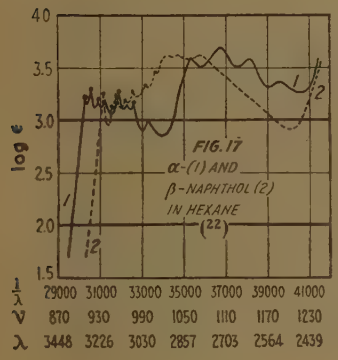


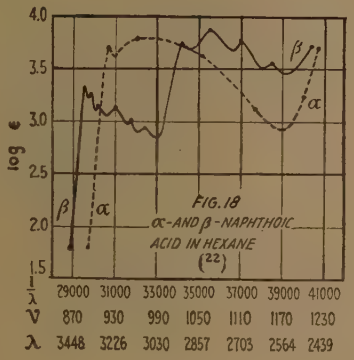
FIG. 13
BENZOIC ACID (1), o-(2), m-(3), AND p-HYDROXY BENZOIC ACID (4) IN HEXANE +10% ETHER (7)
ε
1/λ 30000 32000 34000 36000 38000 40000 42000 44000 46000 48000 50000 52000
ν 900 960 1020 1080 1140 1200 1260 1320 1380 1440 1500 1560
λ 3333 3125 2941 2778 2631 2500 2381 2272 2174 2083 2000 1923

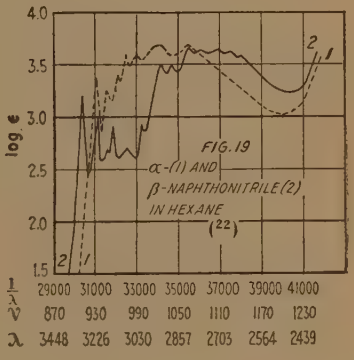

log ε
FIG. 14
α-(1) AND
β-METHYLNAPHTHALENE(2)
IN HEXANE
(21)
1/λ 30000 32000 34000 36000 38000 40000 42000 44000
ν 900 960 1020 1080 1140 1200 1260 1320
λ 3333 3125 2941 2778 2631 2500 2381 2272

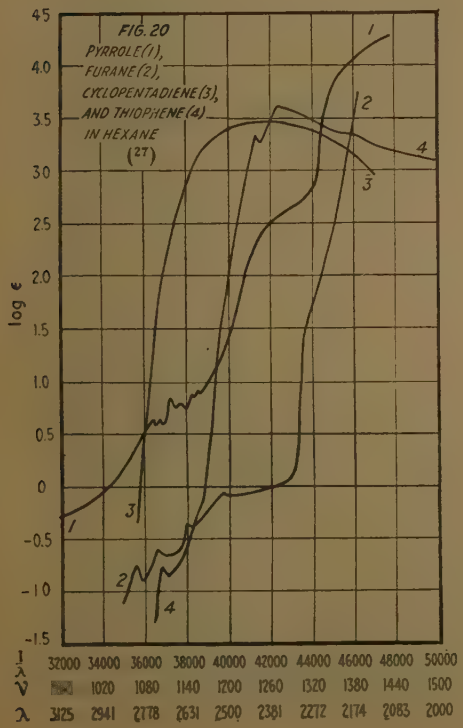

log ε
FIG. 15
2,6-(1) AND 2,
7-DIMETHYLNAPHTHALENE(2)
IN HEXANE
(21)
1/λ 30000 32000 34000 36000 38000 40000 42000 44000
ν 900 960 1020 1080 1140 1200 1260 1320
λ 3333 3125 2941 2778 2631 2500 2381 2272

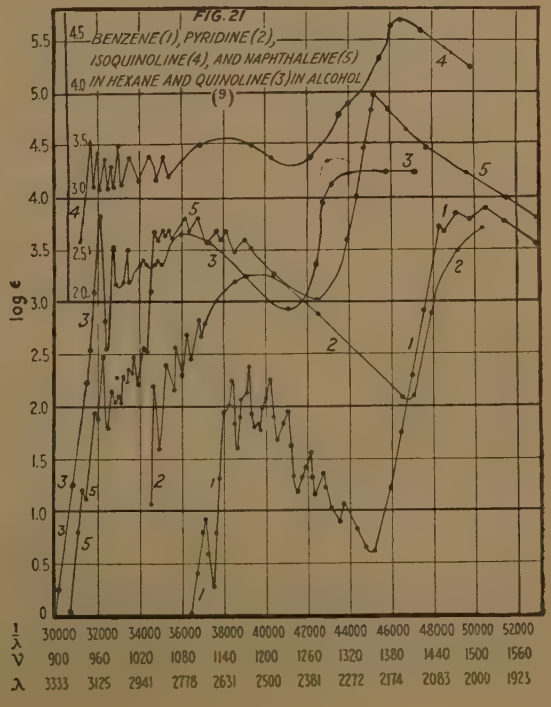

log ε
FIG. 16
α-(1) AND
β-BROMONAPHTHALENE(2)
IN HEXANE
(22)
1/λ 30000 32000 34000 36000 38000 40000 42000
ν 900 960 1020 1080 1140 1200 1260
λ 3333 3125 2941 2778 2631 2500 2381


log ε
FIG. 17
α-(1) AND
β-NAPHTHOL (2)
IN HEXANE
(22)
1/λ 29000 31000 33000 35000 37000 39000 41000
ν 870 930 990 1050 1110 1170 1230
λ 3448 3226 3030 2857 2703 2564 2439


log ε
FIG. 18
α-AND β-NAPHTHOIC
ACID IN HEXANE
(22)
1/λ 29000 31000 33000 35000 37000 39000 41000
ν 870 930 990 1050 1110 1170 1230
λ 3448 3226 3030 2857 2703 2564 2439


log ε
FIG. 19
α-(1) AND
β-NAPHTHONITRILE(2)
IN HEXANE
(22)
1/λ 29000 31000 33000 35000 37000 39000 41000
ν 870 930 990 1050 1110 1170 1230
λ 3448 3226 3030 2857 2703 2564 2439


log ε
FIG. 20
PYRROLE(1),
FURANE(2),
CYCLOPENTADIENE(3),
AND THIOPHENE(4)
IN HEXANE
(27)
1/λ 32000 34000 36000 38000 40000 42000 44000 46000 48000 50000
ν 1020 1080 1140 1200 1260 1320 1380 1440 1500
λ 3125 2941 2778 2631 2500 2381 2272 2174 2083 2000


log ε
FIG. 21
BENZENE(1), PYRIDINE(2),
ISOQUINOLINE(4), AND NAPHTHALENE(5)
IN HEXANE AND QUINOLINE(3) IN ALCOHOL
(9)
1/λ 30000 32000 34000 36000 38000 40000 42000 44000 46000 48000 50000 52000
ν 900 960 1020 1080 1140 1200 1260 1320 1380 1440 1500 1560
λ 3333 3125 2941 2778 2631 2500 2381 2272 2174 2083 2000 1923

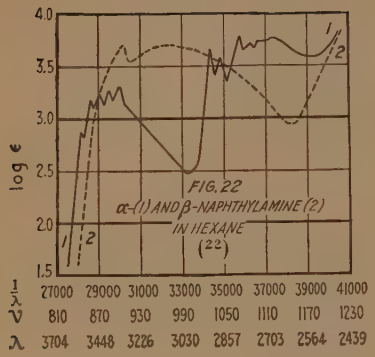


FIG. 22
α-(1) AND β-NAPHTHYLAMINE (2) IN HEXANE (22)

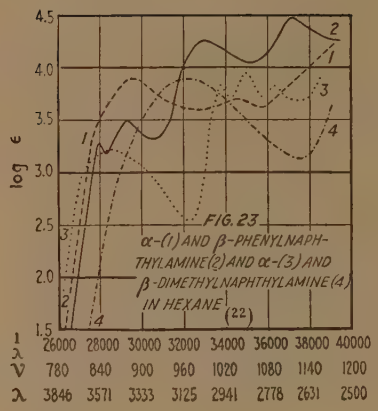


FIG. 23
α-(1) AND β-PHENYLNAPHTHYLAMINE (2) AND α-(3) AND β-DIMETHYLNAPHTHYLAMINE (4) IN HEXANE (22)

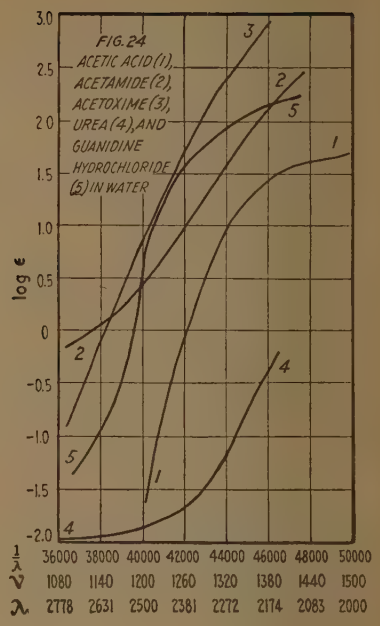


FIG. 24
ACETIC ACID (1), ACETAMIDE (2), ACETOXIME (3), UREA (4), AND GUANIDINE HYDROCHLORIDE (5) IN WATER

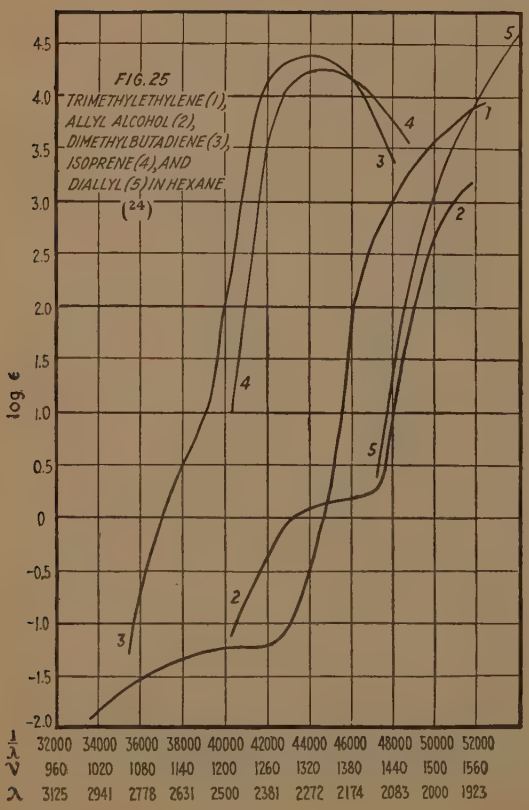


FIG. 25
TRIMETHYLETHYLENE (1), ALLYL ALCOHOL (2), DIMETHYLBUTADIENE (3), ISOPRENE (4), AND DIALLYL (5) IN HEXANE (24)

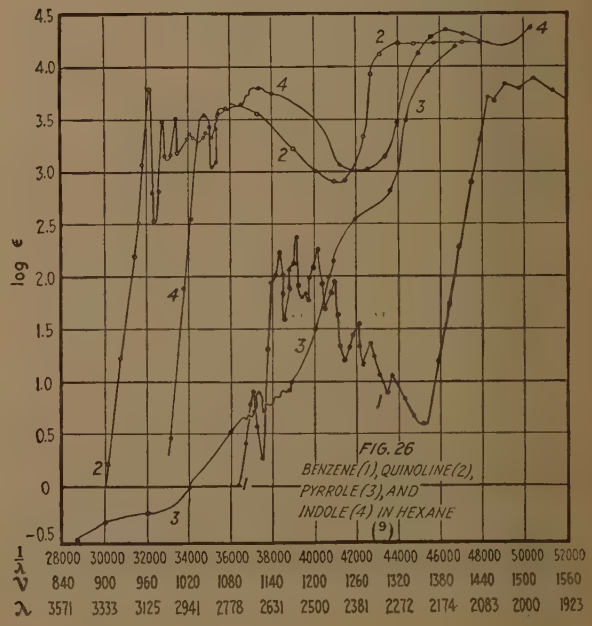
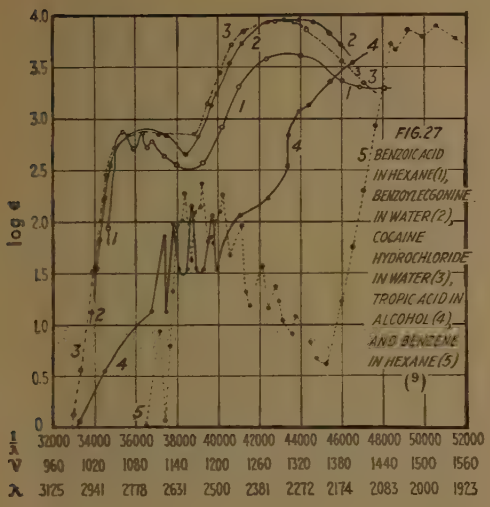
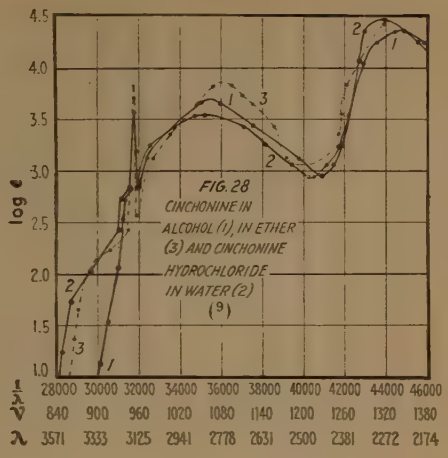
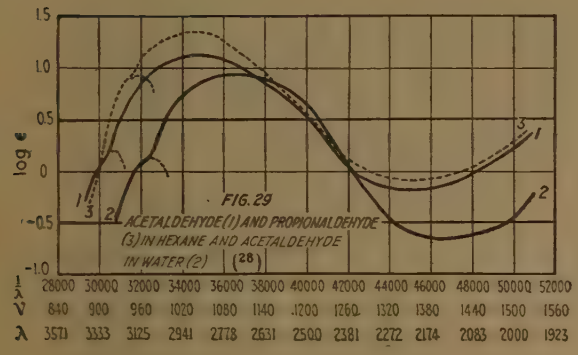
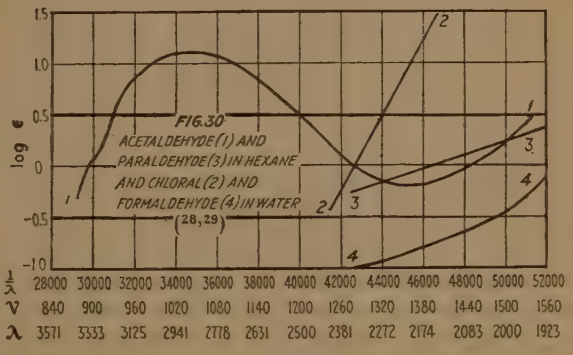


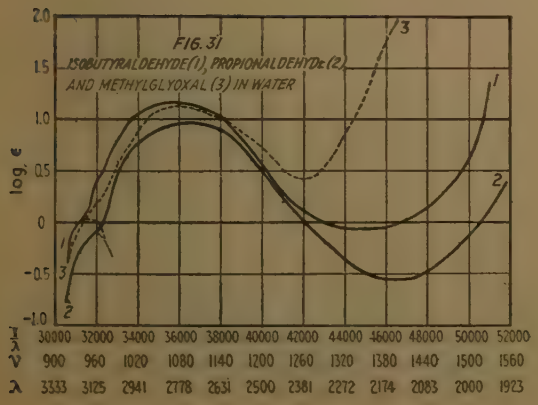
FIG. 26
BENZENE (1), QUINOLINE (2), PYRROLE (3), AND INDOLE (4) IN HEXANE (9)

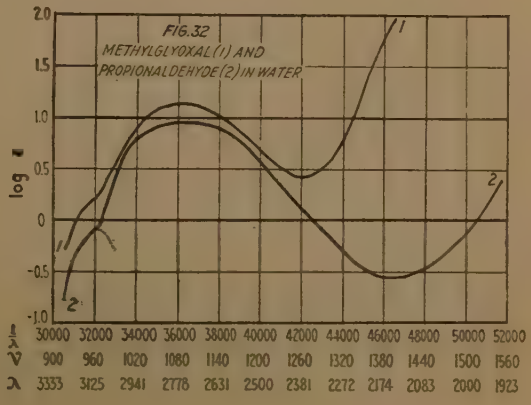

log ε
FIG. 27
BENZOIC ACID IN HEXANE (1), BENZOYLECGONINE IN WATER (2), COCAINE HYDROCHLORIDE IN WATER (3), TROPIC ACID IN ALCOHOL (4), AND BENZENE IN HEXANE (5) (9)
1/λ
ν
λ


log ε
FIG. 28
CINCHONINE IN ALCOHOL (1), IN ETHER (3) AND CINCHONINE HYDROCHLORIDE IN WATER (2) (9)
1/λ
ν
λ


log ε
FIG. 29
ACETALDEHYDE (1) AND PROPIONALDEHYDE (3) IN HEXANE AND ACETALDEHYDE IN WATER (2) (28)
1/λ
ν
λ


log ε
FIG. 30
ACETALDEHYDE (1) AND PARALDEHYDE (3) IN HEXANE AND CHLORAL (2) AND FORMALDEHYDE (4) IN WATER (28,29)
1/λ
ν
λ


log ε
FIG. 31
ISOBUTYRALDEHYDE (1), PROPIONALDEHYDE (2) AND METHYLGLYOXAL (3) IN WATER
1/λ
ν
λ


log ε
FIG. 32
METHYLGLYOXAL (1) AND PROPIONALDEHYDE (2) IN WATER
1/λ
ν
λ

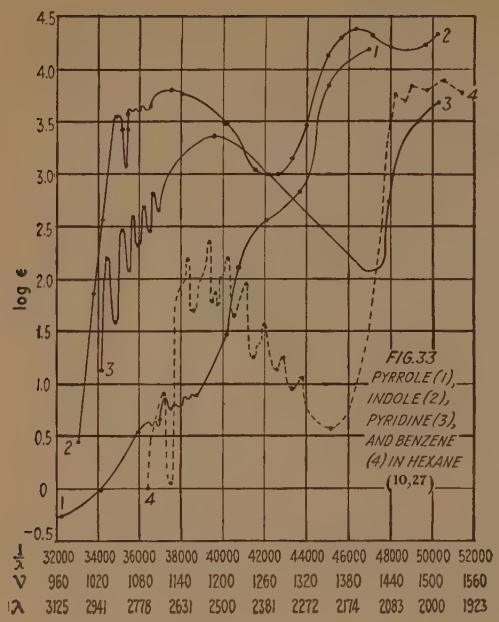


FIG. 33
PYRROLE (1), INDOLE (2), PYRIDINE (3), AND BENZENE (4) IN HEXANE
(10,27)

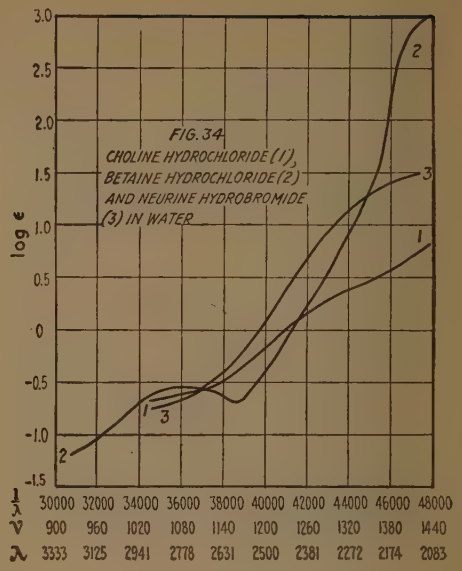


FIG. 34
CHOLINE HYDROCHLORIDE (1), BETAINE HYDROCHLORIDE (2) AND NEURINE HYDROBROMIDE (3) IN WATER

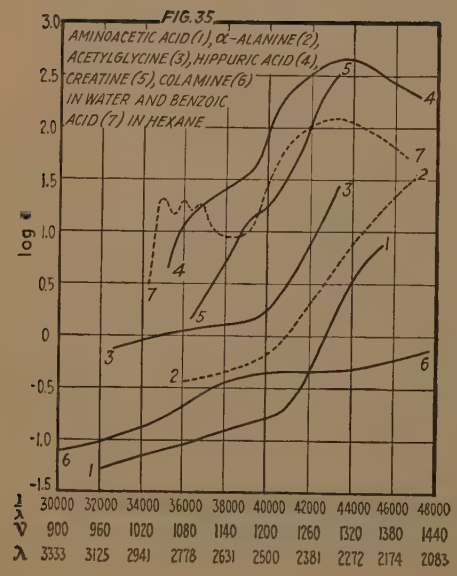


FIG. 35
AMINOACETIC ACID (1), α-ALANINE (2), ACETYLGLYCINE (3), HIPPURIC ACID (4), CREATINE (5), COLAMINE (6) IN WATER AND BENZOIC ACID (7) IN HEXANE

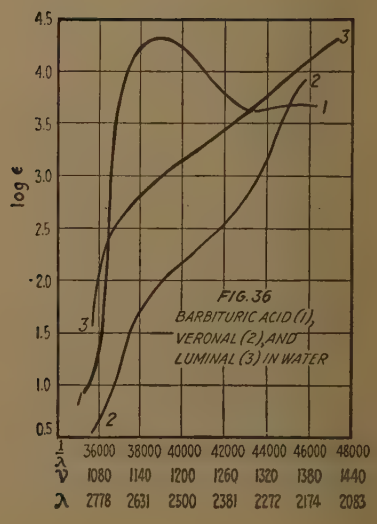


FIG. 36
BARBITURIC ACID (1), VERONAL (2), AND LUMINAL (3) IN WATER

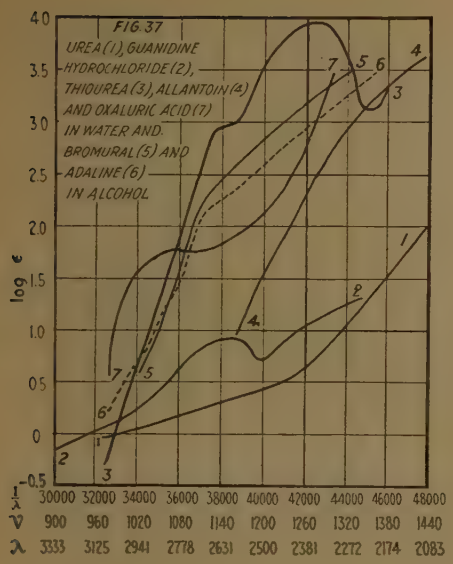


FIG. 37
UREA (1), GUANIDINE HYDROCHLORIDE (2), THIOUREA (3), ALLANTOIN (4) AND OXALURIC ACID (7) IN WATER AND BROMURAL (5) AND ADALINE (6) IN ALCOHOL
log ε
1/λ
ν
λ

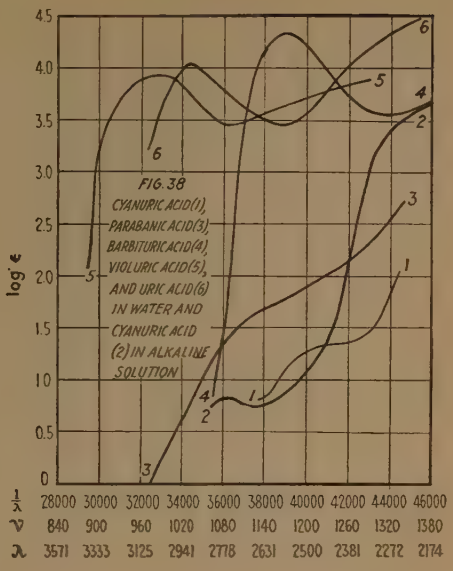


FIG. 38
CYANURIC ACID (1), PARABANIC ACID (3), BARBITURIC ACID (4), VIOLURIC ACID (5), AND URIC ACID (6) IN WATER AND CYANURIC ACID (2) IN ALKALINE SOLUTION
log ε
1/λ
ν
λ

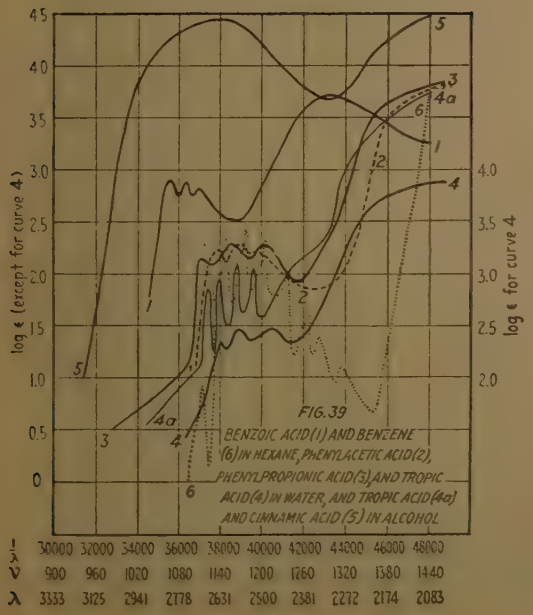


FIG. 39
BENZOIC ACID (1) AND BENZENE (6) IN HEXANE, PHENYLACETIC ACID (2), PHENYLPROPIONIC ACID (3), AND TROPIC ACID (4) IN WATER, AND TROPIC ACID (4a) AND CINNAMIC ACID (5) IN ALCOHOL
log ε (except for curve 4)
log ε for curve 4
1/λ
ν
λ

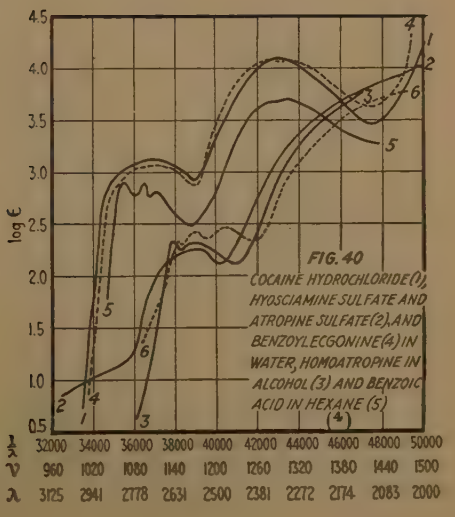


FIG. 40
COCAINE HYDROCHLORIDE (1), HYOSCIAMINE SULFATE AND ATROPINE SULFATE (2), AND BENZOYLECGONINE (4) IN WATER, HOMOATROPINE IN ALCOHOL (3) AND BENZOIC ACID IN HEXANE (5)
log ε
1/λ
ν
λ

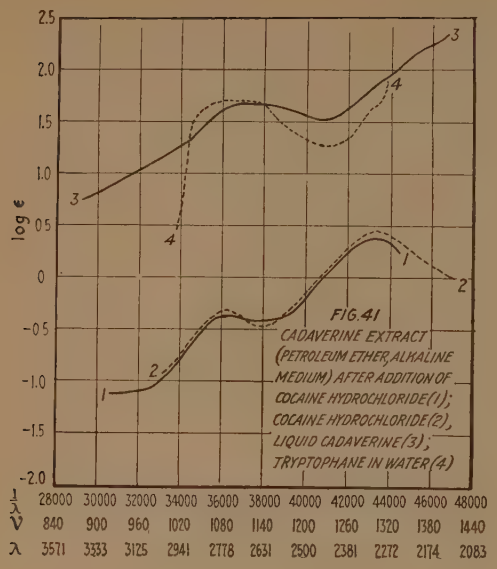
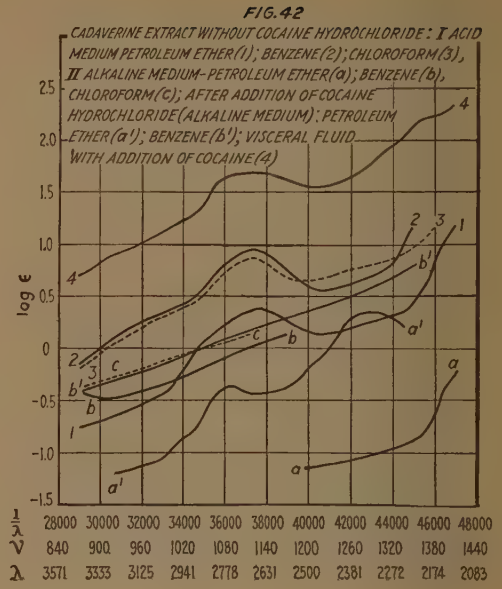


FIG. 41
CADAVERINE EXTRACT (PETROLEUM ETHER, ALKALINE MEDIUM) AFTER ADDITION OF COCAINE HYDROCHLORIDE (1); COCAINE HYDROCHLORIDE (2), LIQUID CADAVERINE (3); TRYPTOPHANE IN WATER (4)

FIG. 42
CADAVERINE EXTRACT WITHOUT COCAINE HYDROCHLORIDE: I ACID MEDIUM PETROLEUM ETHER (1); BENZENE (2); CHLOROFORM (3), II ALKALINE MEDIUM-PETROLEUM ETHER (a); BENZENE (b), CHLOROFORM (c); AFTER ADDITION OF COCAINE HYDROCHLORIDE (ALKALINE MEDIUM): PETROLEUM ETHER (a'); BENZENE (b'); VISCERAL FLUID WITH ADDITION OF COCAINE (4)



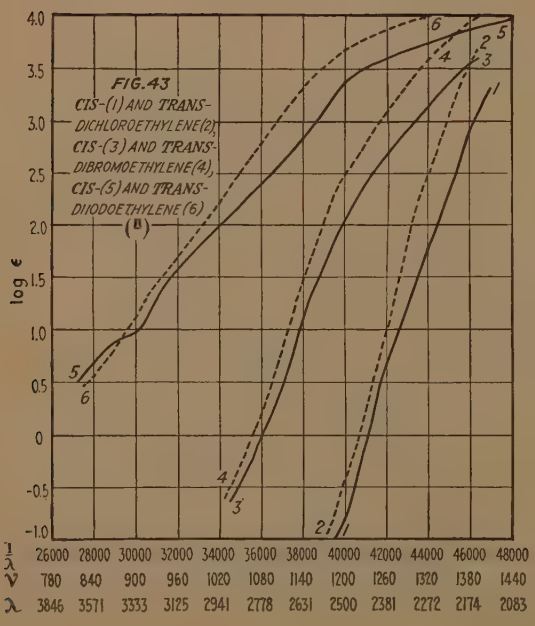


FIG. 43
CIS-(1) AND TRANS-DICHLOROETHYLENE (2); CIS-(3) AND TRANS-DIBROMOETHYLENE (4), CIS-(5) AND TRANS-DIIODOETHYLENE (6)
(B)

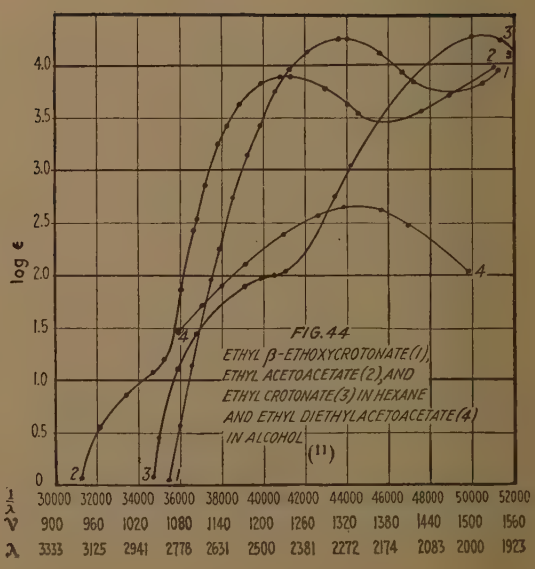


FIG. 44
ETHYL β-ETHOXYCROTONATE (1), ETHYL ACETOACETATE (2), AND ETHYL CROTONATE (3) IN HEXANE AND ETHYL DIETHYLACETOACETATE (4) IN ALCOHOL
(11)

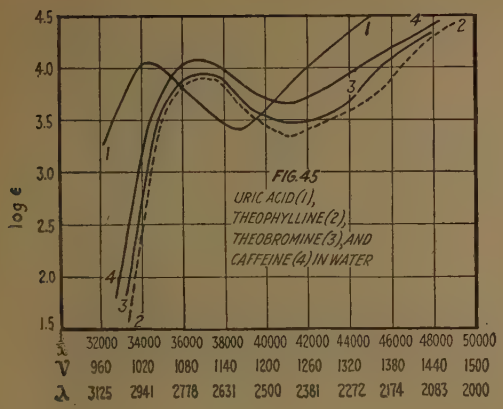


FIG. 45
URIC ACID (1), THEOPHYLLINE (2), THEOBROMINE (3), AND CAFFEINE (4) IN WATER

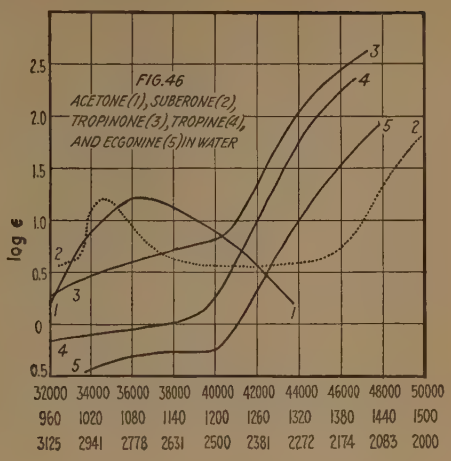


FIG. 46
ACETONE (1), SUBERONE (2), TROPINONE (3), TROPINE (4), AND ECGONINE (5) IN WATER

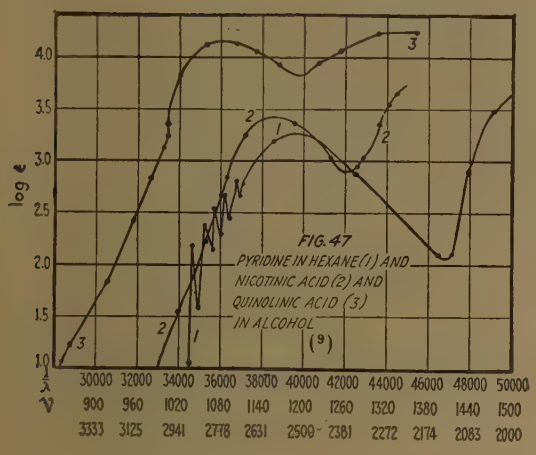


FIG. 47
PYRIDINE IN HEXANE (1) AND NICOTINIC ACID (2) AND QUINOLINIC ACID (3) IN ALCOHOL (9)

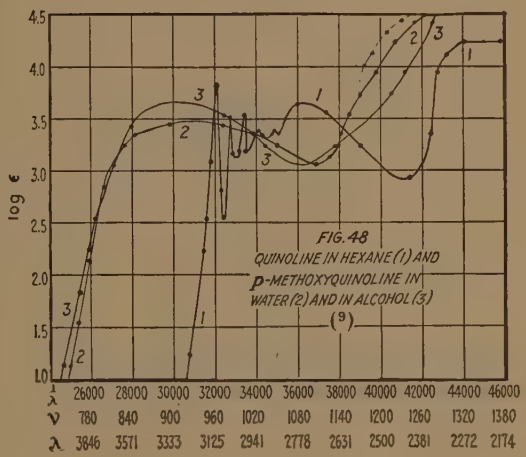


FIG. 48
QUINOLINE IN HEXANE (1) AND p-METHOXYQUINOLINE IN WATER (2) AND IN ALCOHOL (3) (9)

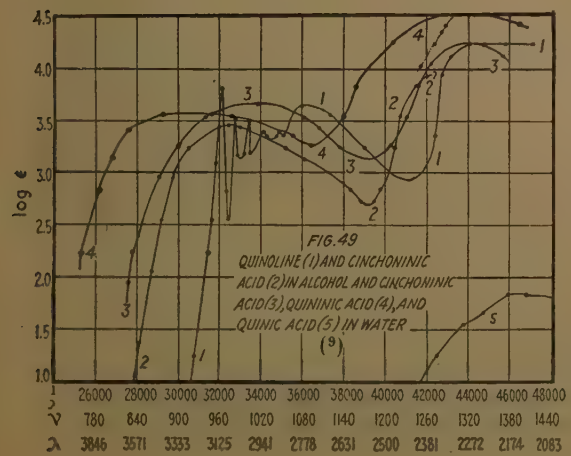


FIG. 49
QUINOLINE (1) AND CINCHONINIC ACID (2) IN ALCOHOL AND CINCHONINIC ACID (3), QUININIC ACID (4), AND QUINIC ACID (5) IN WATER (9)

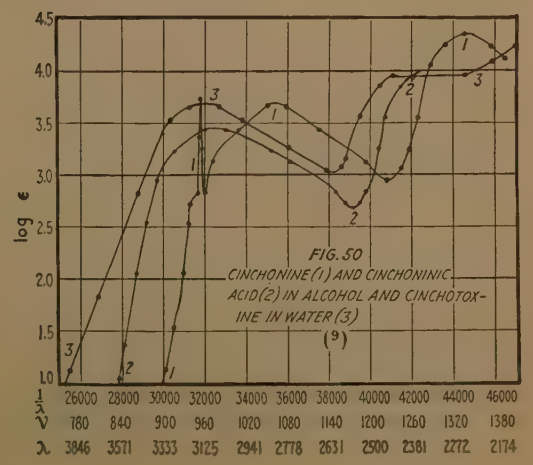


FIG. 50
CINCHONINE (1) AND CINCHONINIC ACID (2) IN ALCOHOL AND CINCHOTOXINE IN WATER (3) (9)

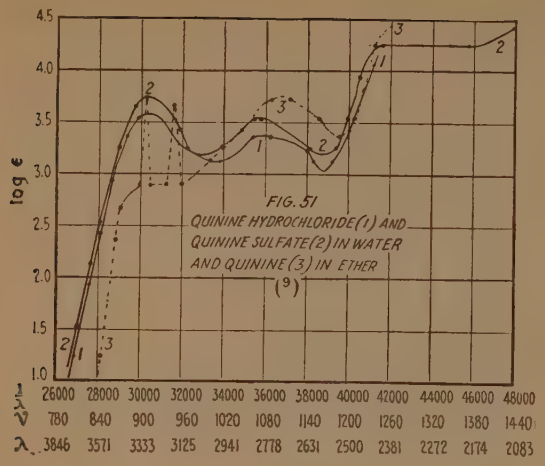


FIG. 51
QUININE HYDROCHLORIDE (1) AND QUININE SULFATE (2) IN WATER AND QUININE (3) IN ETHER
(9)

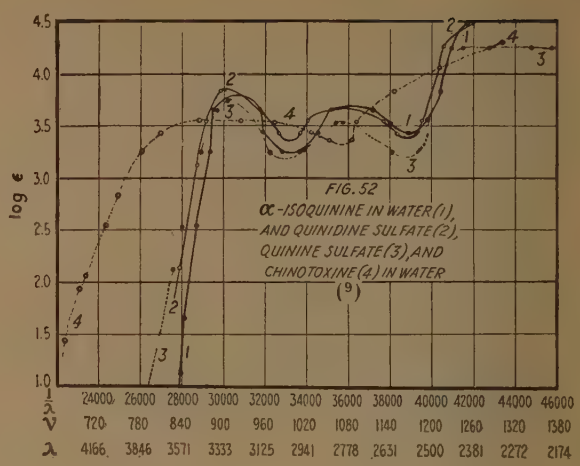


FIG. 52
α-ISOQUININE IN WATER (1), AND QUINIDINE SULFATE (2), QUININE SULFATE (3), AND CHINOTOXINE (4) IN WATER
(9)

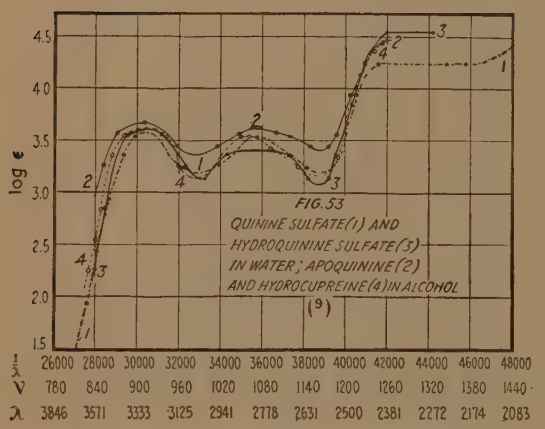


FIG. 53
QUININE SULFATE (1) AND HYDROQUININE SULFATE (3) IN WATER; APOQUININE (2) AND HYDROCUPREINE (4) IN ALCOHOL
(9)

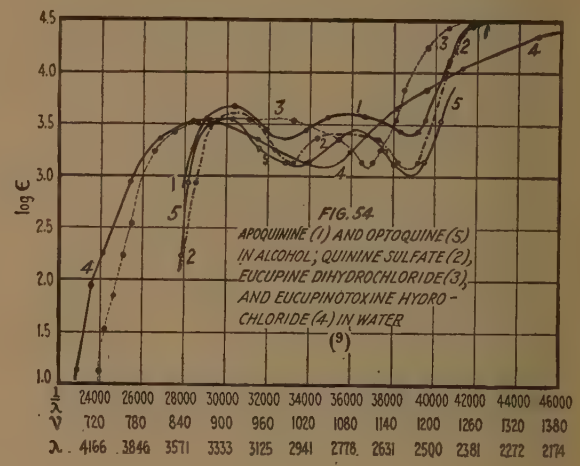


FIG. 54
APOQUININE (1) AND OPTOQUINE (5) IN ALCOHOL; QUININE SULFATE (2), EUCUPINE DIHYDROCHLORIDE (3), AND EUCUPINOTOXINE HYDROCHLORIDE (4) IN WATER
(9)

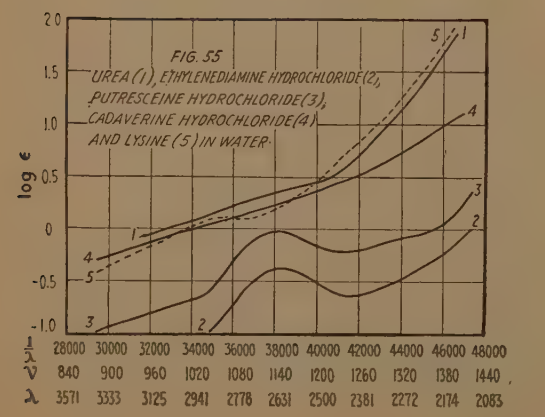


FIG. 55
UREA (1), ETHYLENEDIAMINE HYDROCHLORIDE (2), PUTRESCEINE HYDROCHLORIDE (3), CADAVERINE HYDROCHLORIDE (4) AND LYSINE (5) IN WATER

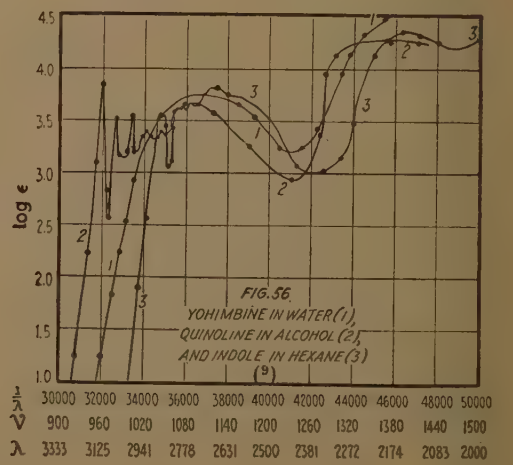
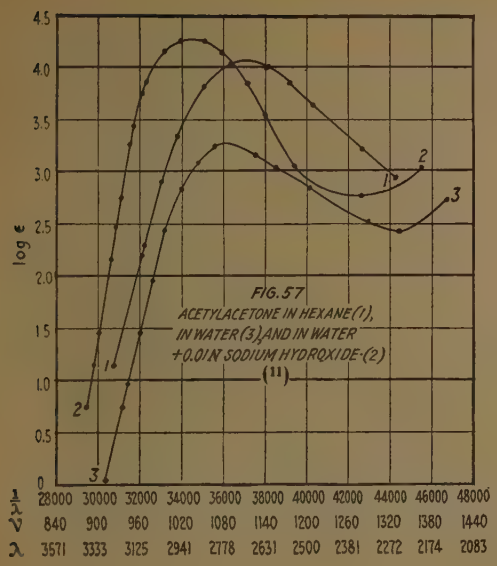
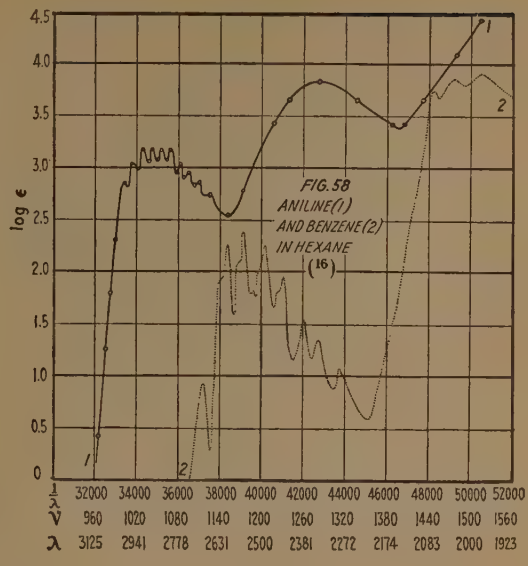
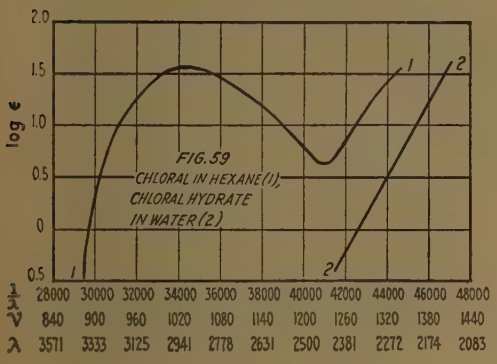
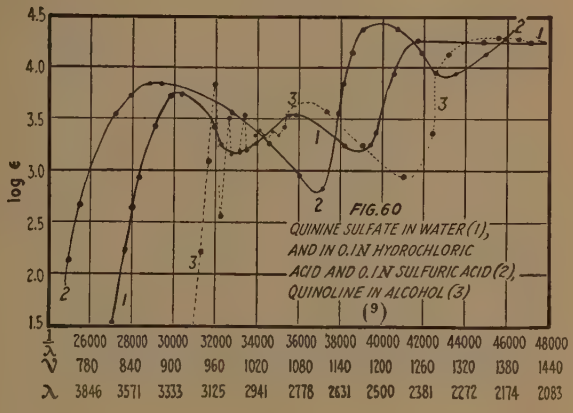


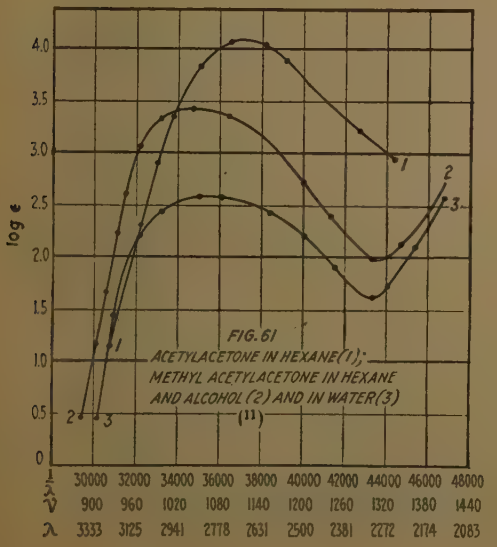
FIG. 56
YOHIMBINE IN WATER (1), QUINOLINE IN ALCOHOL (2), AND INDOLE IN HEXANE (3)
(9)

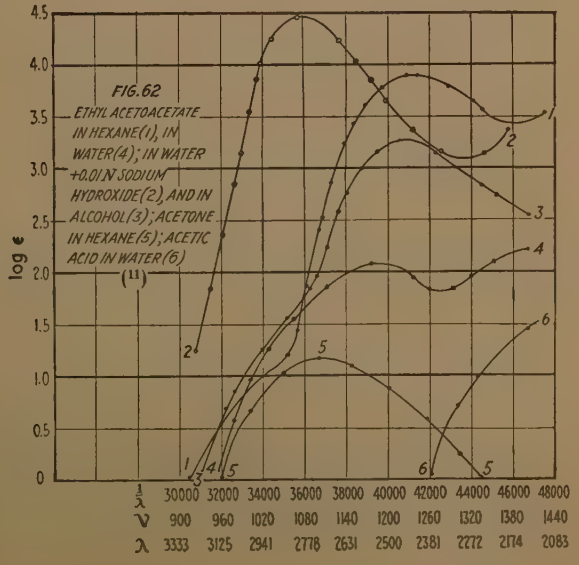

log ε
FIG. 57
ACETYLACETONE IN HEXANE (1), IN WATER (3), AND IN WATER +0.01 N SODIUM HYDROXIDE (2)
(11)
1/λ 28000 30000 32000 34000 36000 38000 40000 42000 44000 46000 48000
ν 840 900 960 1020 1080 1140 1200 1260 1320 1380 1440
λ 3571 3333 3125 2941 2778 2631 2500 2381 2272 2174 2083


log ε
FIG. 58
ANILINE (1) AND BENZENE (2) IN HEXANE
(16)
1/λ 32000 34000 36000 38000 40000 42000 44000 46000 48000 50000 52000
ν 960 1020 1080 1140 1200 1260 1320 1380 1440 1500 1560
λ 3125 2941 2778 2631 2500 2381 2272 2174 2083 2000 1923


log ε
FIG. 59
CHLORAL IN HEXANE (1), CHLORAL HYDRATE IN WATER (2)
1/λ 28000 30000 32000 34000 36000 38000 40000 42000 44000 46000 48000
ν 840 900 960 1020 1080 1140 1200 1260 1320 1380 1440
λ 3571 3333 3125 2941 2778 2631 2500 2381 2272 2174 2083


log ε
FIG. 60
QUININE SULFATE IN WATER (1), AND IN 0.1 N HYDROCHLORIC ACID AND 0.1 N SULFURIC ACID (2), QUINOLINE IN ALCOHOL (3)
(9)
1/λ 26000 28000 30000 32000 34000 36000 38000 40000 42000 44000 46000 48000
ν 780 840 900 960 1020 1080 1140 1200 1260 1320 1380 1440
λ 3846 3571 3333 3125 2941 2778 2631 2500 2381 2272 2174 2083


log ε
FIG. 61
ACETYLACETONE IN HEXANE (1); METHYL ACETYLACETONE IN HEXANE AND ALCOHOL (2) AND IN WATER (3)
(11)
1/λ 30000 32000 34000 36000 38000 40000 42000 44000 46000 48000
ν 900 960 1020 1080 1140 1200 1260 1320 1380 1440
λ 3333 3125 2941 2778 2631 2500 2381 2272 2174 2083


log ε
FIG. 62
ETHYL ACETOACETATE IN HEXANE (1), IN WATER (4); IN WATER +0.01 N SODIUM HYDROXIDE (2), AND IN ALCOHOL (3); ACETONE IN HEXANE (5); ACETIC ACID IN WATER (6)
(11)
1/λ 30000 32000 34000 36000 38000 40000 42000 44000 46000 48000
ν 900 960 1020 1080 1140 1200 1260 1320 1380 1440
λ 3333 3125 2941 2778 2631 2500 2381 2272 2174 2083

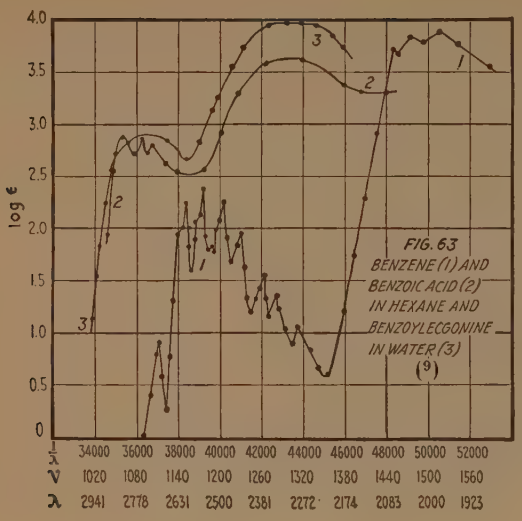


FIG. 63
BENZENE (1) AND BENZOIC ACID (2) IN HEXANE AND BENZOYLECGONINE IN WATER (3)
(9)

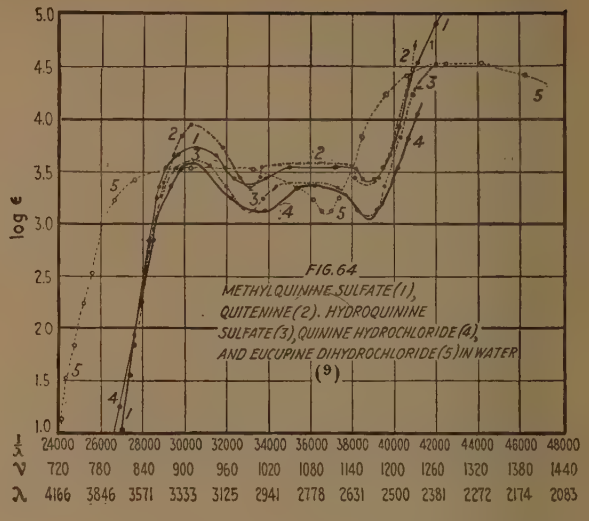


FIG. 64
METHYLQUINNE SULFATE (1), QUITENINE (2). HYDROQUININE SULFATE (3), QUININE HYDROCHLORIDE (4), AND EUCUPINE DIHYDROCHLORIDE (5) IN WATER
(9)

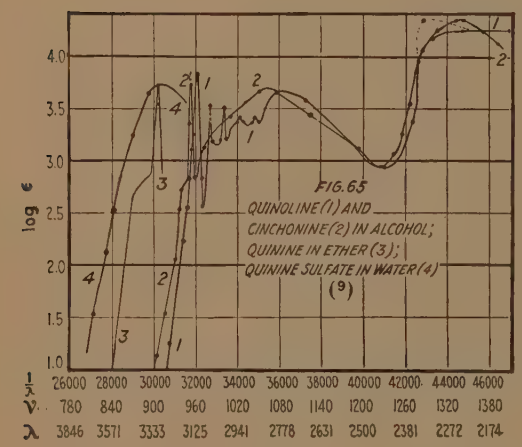


FIG. 65
QUINOLINE (1) AND CINCHONINE (2) IN ALCOHOL; QUININE IN ETHER (3); QUININE SULFATE IN WATER (4)
(9)

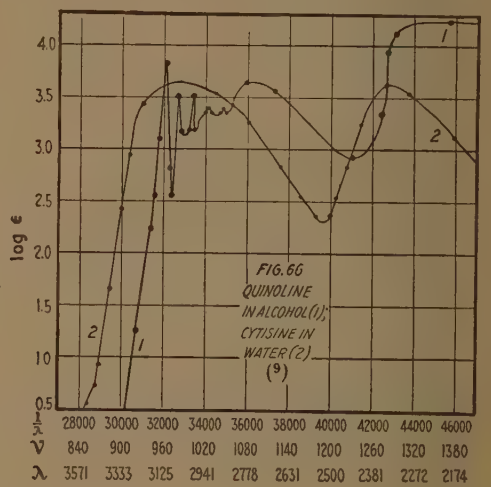


FIG. 66
QUINOLINE IN ALCOHOL (1); CYTISINE IN WATER (2)
(9)

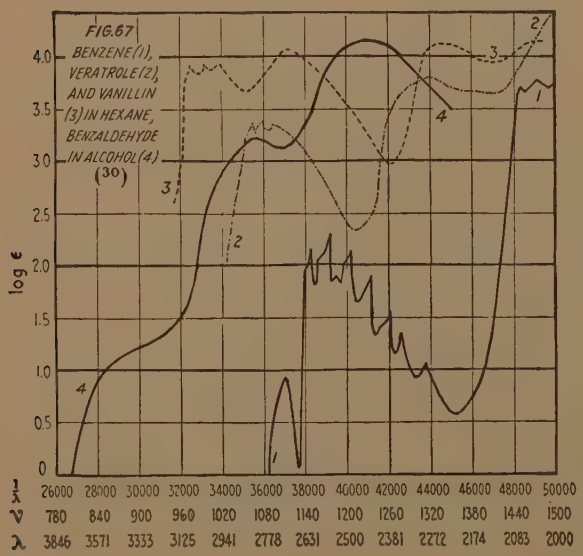


FIG. 67
BENZENE (1), VERATROLE (2), AND VANILLIN (3) IN HEXANE, BENZALDEHYDE IN ALCOHOL (4)
(30)

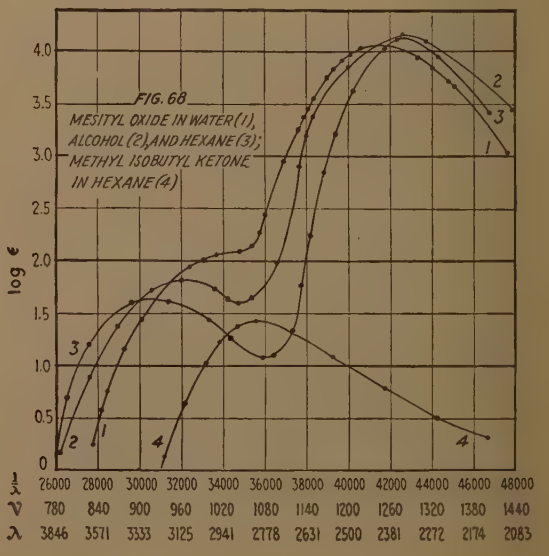
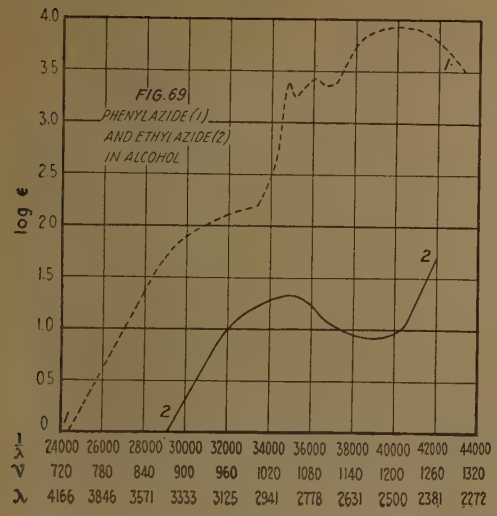
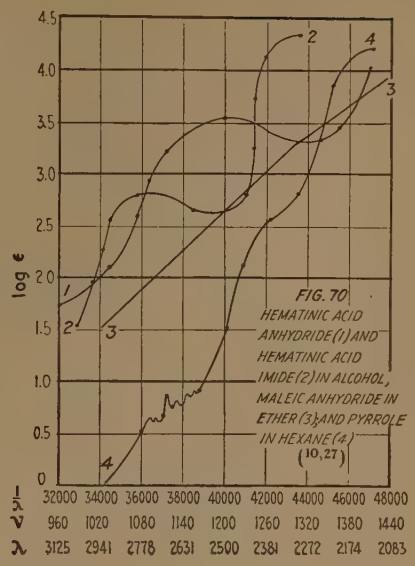
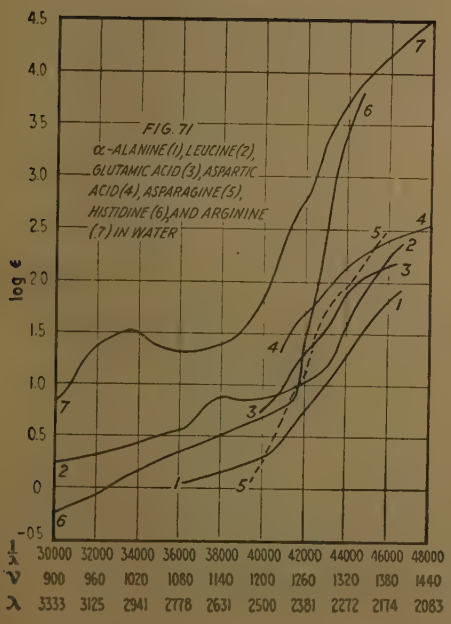
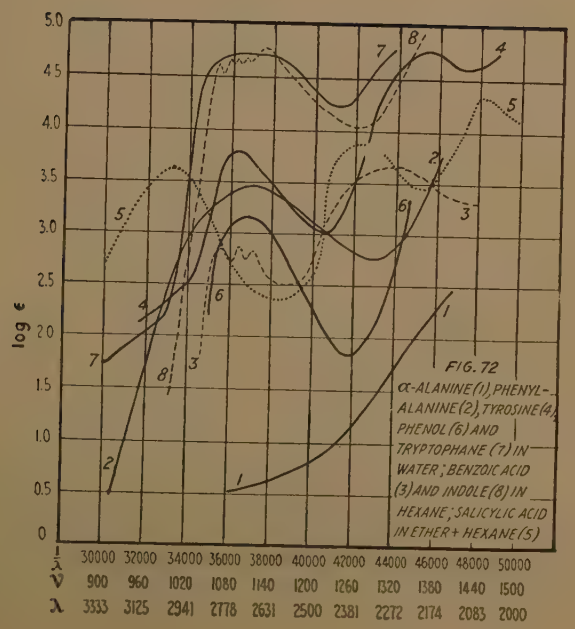


FIG. 68
MESITYL OXIDE IN WATER (1), ALCOHOL (2), AND HEXANE (3); METHYL ISOBUTYL KETONE IN HEXANE (4)


log ε
FIG. 69
PHENYLAZIDE (1) AND ETHYLAZIDE (2) IN ALCOHOL
1/λ 24000 26000 28000 30000 32000 34000 36000 38000 40000 42000 44000
ν 720 780 840 900 960 1020 1080 1140 1200 1260 1320
λ 4166 3846 3571 3333 3125 2941 2778 2631 2500 2381 2272


log ε
FIG. 70
HEMATINIC ACID ANHYDRIDE (1) AND HEMATINIC ACID IMIDE (2) IN ALCOHOL, MALEIC ANHYDRIDE IN ETHER (3) AND PYRROLE IN HEXANE (4) (10,27)
1/λ 32000 34000 36000 38000 40000 42000 44000 46000 48000
ν 960 1020 1080 1140 1200 1260 1320 1380 1440
λ 3125 2941 2778 2631 2500 2381 2272 2174 2083


log ε
FIG. 71
α-ALANINE (1), LEUCINE (2), GLUTAMIC ACID (3), ASPARTIC ACID (4), ASPARAGINE (5), HISTIDINE (6), AND ARGININE (7) IN WATER
1/λ 30000 32000 34000 36000 38000 40000 42000 44000 46000 48000
ν 900 960 1020 1080 1140 1200 1260 1320 1380 1440
λ 3333 3125 2941 2778 2631 2500 2381 2272 2174 2083


log ε
FIG. 72
α-ALANINE (1), PHENYL-ALANINE (2), TYROSINE (4), PHENOL (6) AND TRYPTOPHANE (7) IN WATER; BENZOIC ACID (3) AND INDOLE (8) IN HEXANE; SALICYLIC ACID IN ETHER + HEXANE (5)
1/λ 30000 32000 34000 36000 38000 40000 42000 44000 46000 48000 50000
ν 900 960 1020 1080 1140 1200 1260 1320 1380 1440 1500
λ 3333 3125 2941 2778 2631 2500 2381 2272 2174 2083 2000

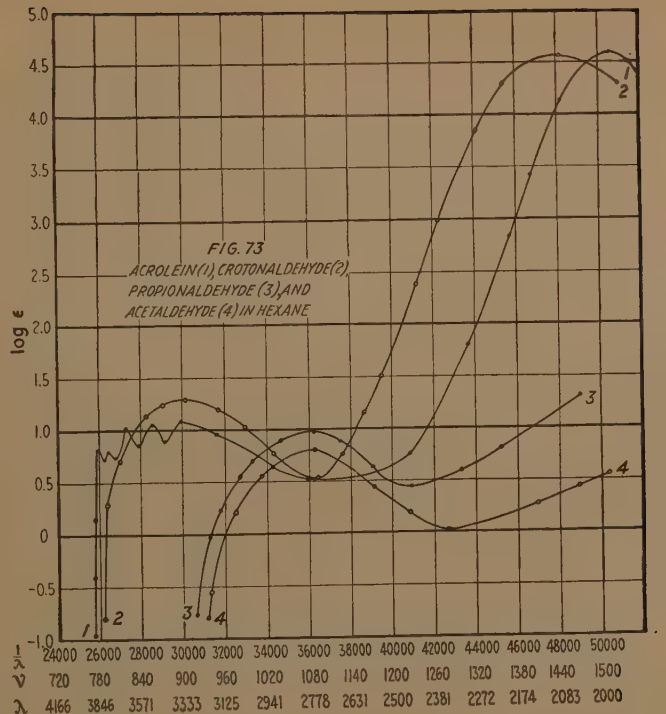


FIG. 73
ACROLEIN(1), CROTONALDEHYDE(2), PROPIONALDEHYDE (3), AND ACETALDEHYDE (4) IN HEXANE
log ε
5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0 -0.5 -1.0
ν 24000 26000 28000 30000 32000 34000 36000 38000 40000 42000 44000 46000 48000 50000
ν×10⁻³ 720 780 840 900 960 1020 1080 1140 1200 1260 1320 1380 1440 1500
λ 4166 3846 3571 3333 3125 2941 2778 2631 2500 2381 2272 2174 2083 2000

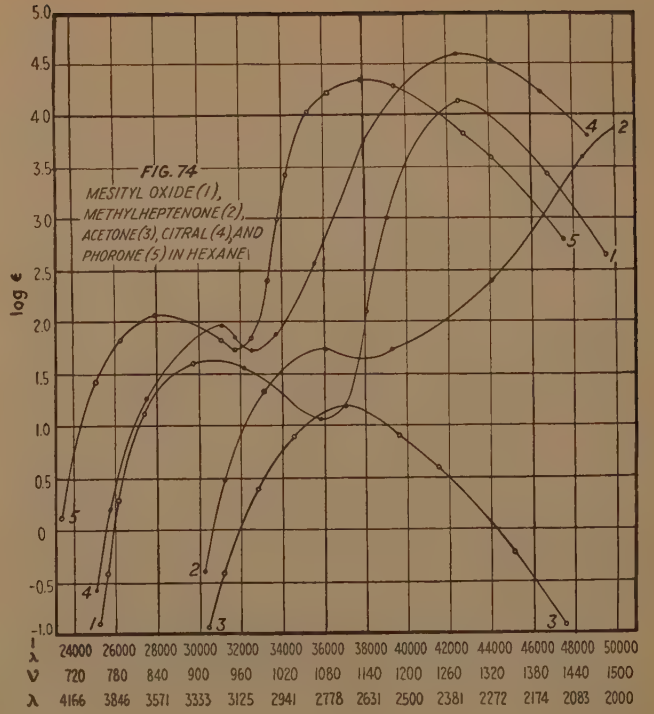


FIG. 74
MESITYL OXIDE (1), METHYLHEPTENONE (2), ACETONE (3), CITRAL (4), AND PHORONE (5) IN HEXANE
log ε
5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0 -0.5 -1.0
ν 24000 26000 28000 30000 32000 34000 36000 38000 40000 42000 44000 46000 48000 50000
ν×10⁻³ 720 780 840 900 960 1020 1080 1140 1200 1260 1320 1380 1440 1500
λ 4166 3846 3571 3333 3125 2941 2778 2631 2500 2381 2272 2174 2083 2000

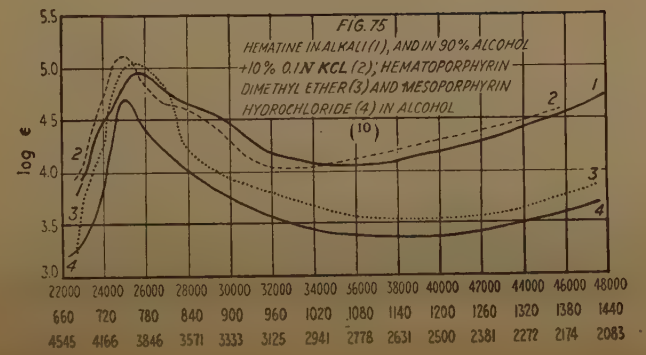


FIG. 75
HEMATINE IN ALKALI (1), AND IN 90% ALCOHOL +10% 0.1 N KCL (2); HEMATOPORPHYRIN DIMETHYL ETHER (3) AND MESOPORPHYRIN HYDROCHLORIDE (4) IN ALCOHOL
(10)
log ε
5.5 5.0 4.5 4.0 3.5 3.0
ν 22000 24000 26000 28000 30000 32000 34000 36000 38000 40000 42000 44000 46000 48000
ν×10⁻³ 660 720 780 840 900 960 1020 1080 1140 1200 1260 1320 1380 1440
λ 4545 4166 3846 3571 3333 3125 2941 2778 2631 2500 2381 2272 2174 2083

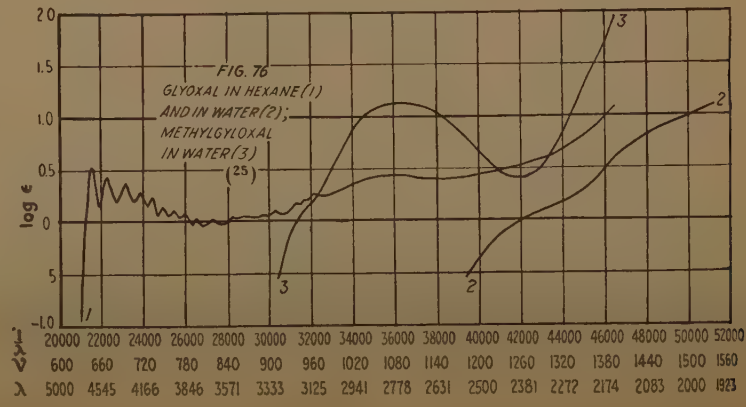


FIG. 76
GLYOXAL IN HEXANE (1) AND IN WATER (2); METHYLGLYOXAL IN WATER (3)
(25)
log ε
2.0 1.5 1.0 0.5 0 .5 -1.0
ν 20000 22000 24000 26000 28000 30000 32000 34000 36000 38000 40000 42000 44000 46000 48000 50000 52000
ν×10⁻³ 600 660 720 780 840 900 960 1020 1080 1140 1200 1260 1320 1380 1440 1500 1560
λ 5000 4545 4166 3846 3571 3333 3125 2941 2778 2631 2500 2381 2272 2174 2083 2000 1923

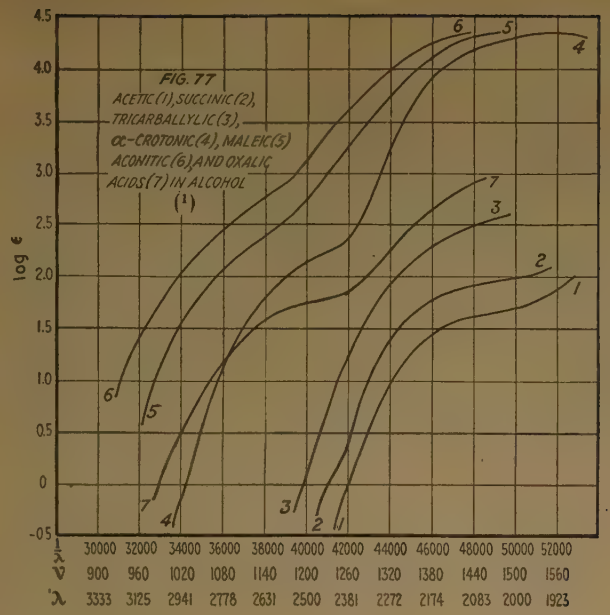


FIG. 77
ACETIC (1), SUCCINIC (2), TRICARBALLYLIC (3), α-CROTONIC (4), MALEIC (5) ACONITIC (6), AND OXALIC ACIDS (7) IN ALCOHOL
(1)
log ε
1/λ 30000 32000 34000 36000 38000 40000 42000 44000 46000 48000 50000 52000
ν 900 960 1020 1080 1140 1200 1260 1320 1380 1440 1500 1560
λ 3333 3125 2941 2778 2631 2500 2381 2272 2174 2083 2000 1923

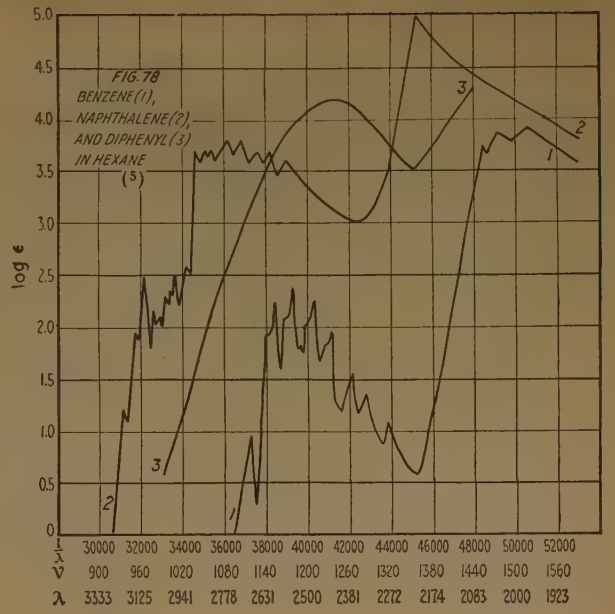


FIG. 78
BENZENE (1), NAPHTHALENE (2), AND DIPHENYL (3) IN HEXANE
(5)
log ε
1/λ 30000 32000 34000 36000 38000 40000 42000 44000 46000 48000 50000 52000
ν 900 960 1020 1080 1140 1200 1260 1320 1380 1440 1500 1560
λ 3333 3125 2941 2778 2631 2500 2381 2272 2174 2083 2000 1923

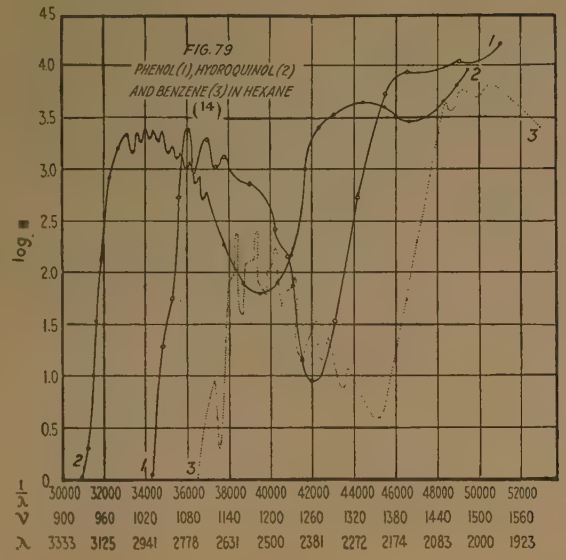


FIG. 79
PHENOL (1), HYDROQUINOL (2) AND BENZENE (3) IN HEXANE
(14)
log ε
1/λ 30000 32000 34000 36000 38000 40000 42000 44000 46000 48000 50000 52000
ν 900 960 1020 1080 1140 1200 1260 1320 1380 1440 1500 1560
λ 3333 3125 2941 2778 2631 2500 2381 2272 2174 2083 2000 1923

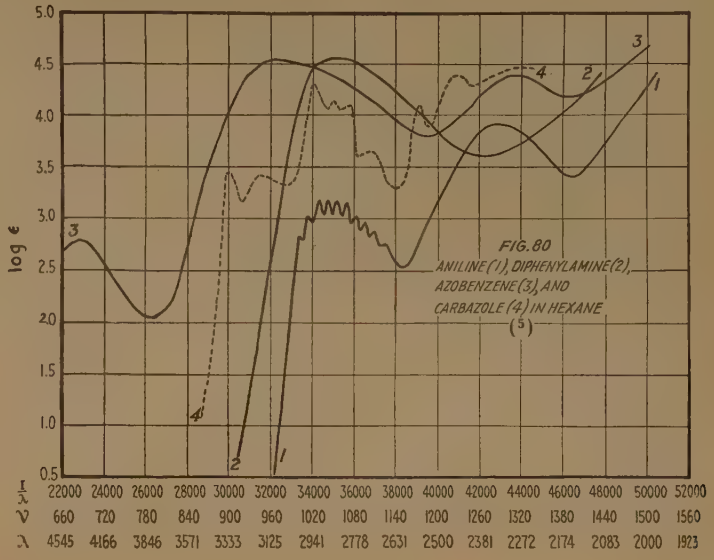


FIG. 80
ANILINE (1), DIPHENYLAMINE (2), AZOBENZENE (3), AND CARBAZOLE (4) IN HEXANE
(5)
log ε
1/λ 22000 24000 26000 28000 30000 32000 34000 36000 38000 40000 42000 44000 46000 48000 50000 52000
ν 660 720 780 840 900 960 1020 1080 1140 1200 1260 1320 1380 1440 1500 1560
λ 4545 4166 3846 3571 3333 3125 2941 2778 2631 2500 2381 2272 2174 2083 2000 1923

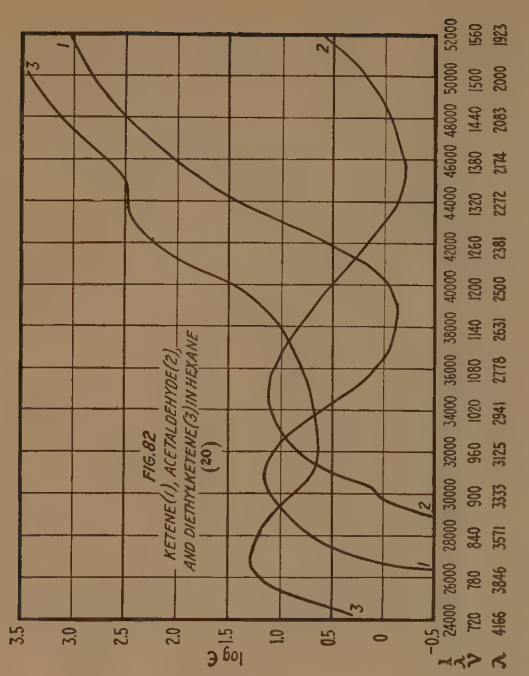


FIG. 82
KETENE(1), ACETALDEHYDE(2), AND DIETHYLKETENE(3) IN HEXANE (20)
log ε
1/λ 24000 26000 28000 30000 32000 34000 36000 38000 40000 42000 44000 46000 48000 50000 52000
ν 720 780 840 900 960 1020 1080 1140 1200 1260 1320 1380 1440 1500 1560
λ 4166 3846 3571 3333 3125 2941 2778 2631 2500 2381 2272 2174 2083 2000 1923

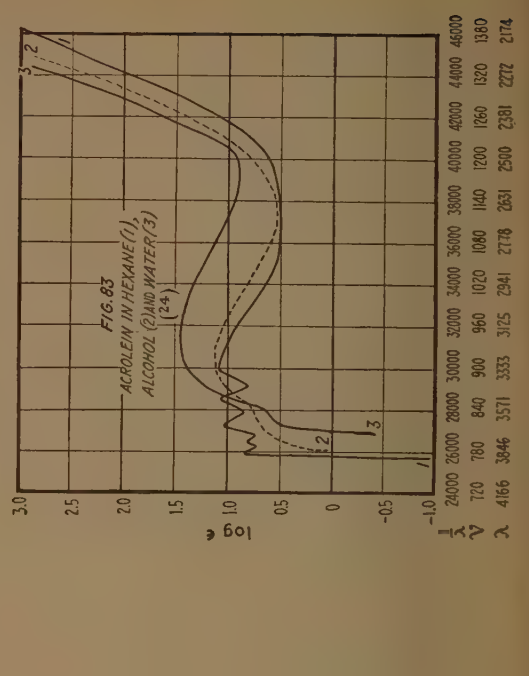


FIG. 83
ACROLEIN IN HEXANE(1), ALCOHOL (2) AND WATER (3) (24)
log ε
1/λ 24000 26000 28000 30000 32000 34000 36000 38000 40000 42000 44000 46000
ν 720 780 840 900 960 1020 1080 1140 1200 1260 1320 1380
λ 4166 3846 3571 3333 3125 2941 2778 2631 2500 2381 2272 2174

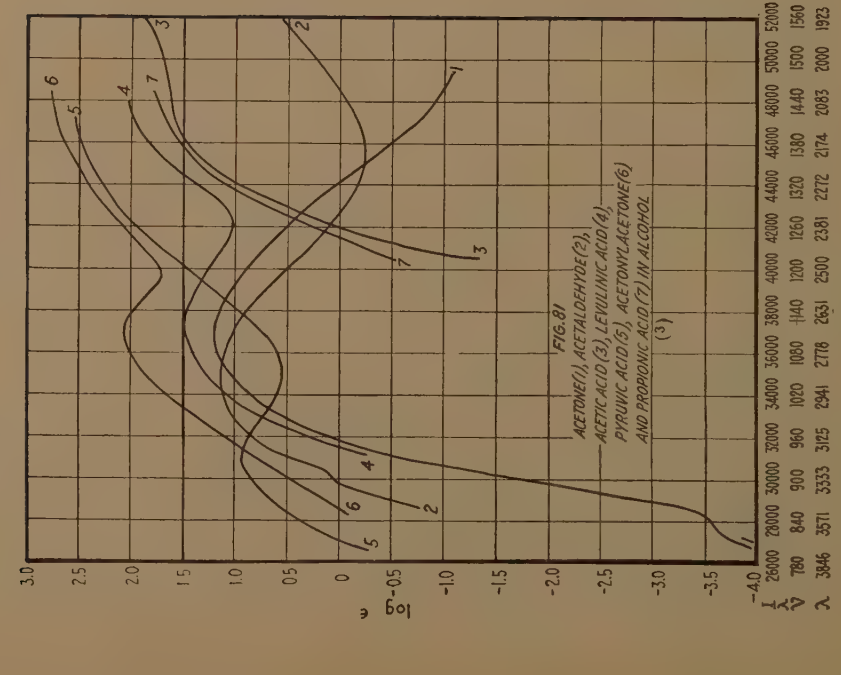


FIG. 81
ACETONE(1), ACETALDEHYDE(2), ACETIC ACID(3), LEVULINIC ACID(4), PYRUVIC ACID(5), ACETONYLACETONE(6) AND PROPIONIC ACID(7) IN ALCOHOL (3)
log ε
1/λ 26000 28000 30000 32000 34000 36000 38000 40000 42000 44000 46000 48000 50000 52000
ν 780 840 900 960 1020 1080 1140 1200 1260 1320 1380 1440 1500 1560
λ 3846 3571 3333 3125 2941 2778 2631 2500 2381 2272 2174 2083 2000 1923

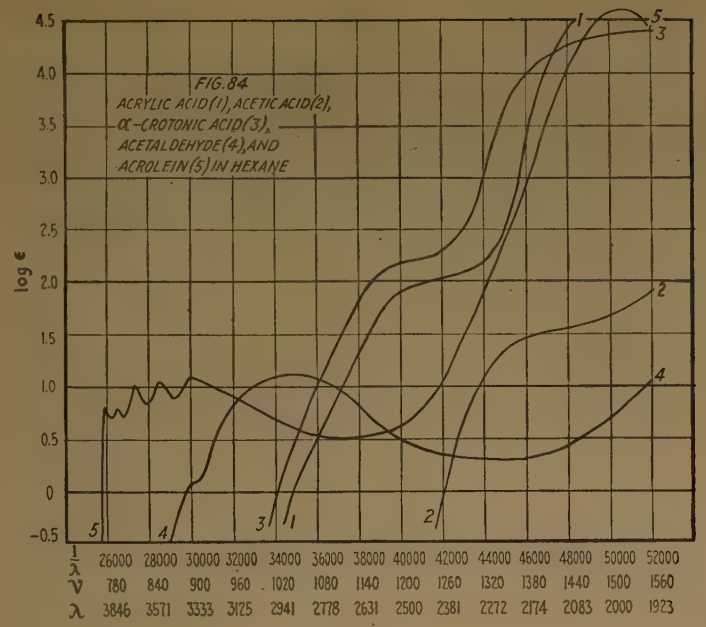


FIG. 84
ACRYLIC ACID (1), ACETIC ACID (2), α-CROTONIC ACID (3), ACETALDEHYDE (4), AND ACROLEIN (5) IN HEXANE
log ε
1/λ 26000 28000 30000 32000 34000 36000 38000 40000 42000 44000 46000 48000 50000 52000
ν 780 840 900 960 1020 1080 1140 1200 1260 1320 1380 1440 1500 1560
λ 3846 3571 3333 3125 2941 2778 2631 2500 2381 2272 2174 2083 2000 1923

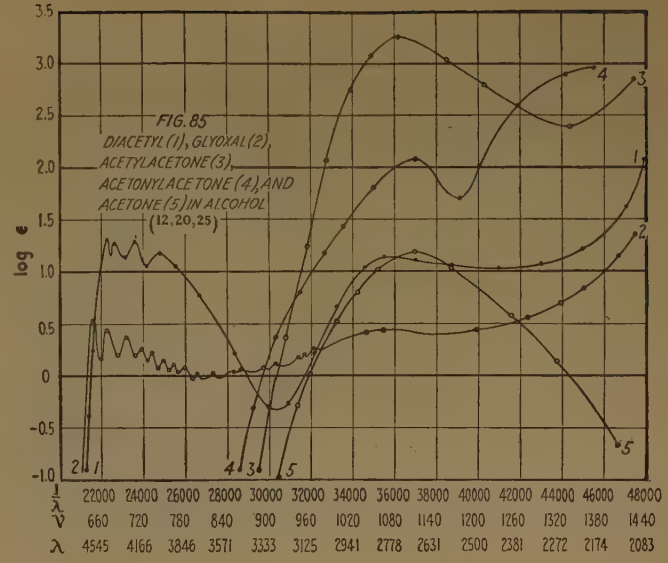


FIG. 85
DIACETYL (1), GLYOXAL (2), ACETYLACETONE (3), ACETONYLACETONE (4), AND ACETONE (5) IN ALCOHOL
(12, 20, 25)
log ε
1/λ 22000 24000 26000 28000 30000 32000 34000 36000 38000 40000 42000 44000 46000 48000
ν 660 720 780 840 900 960 1020 1080 1140 1200 1260 1320 1380 1440
λ 4545 4166 3846 3571 3333 3125 2941 2778 2631 2500 2381 2272 2174 2083

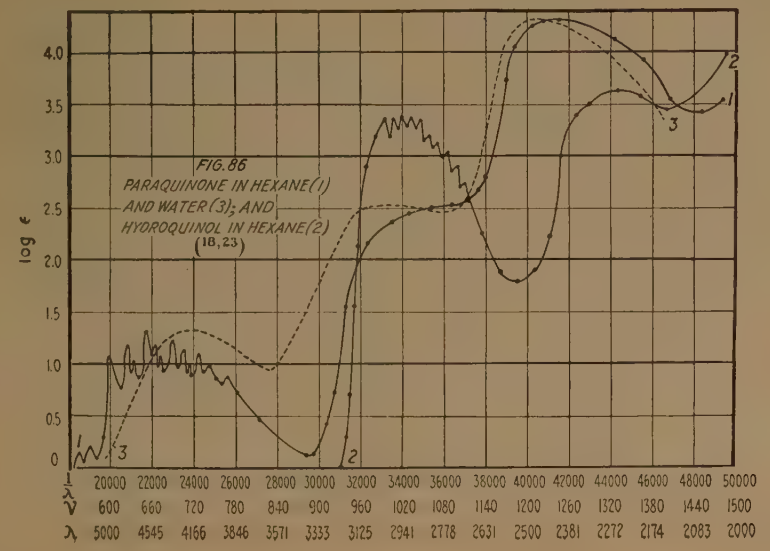


FIG. 86
PARAQUINONE IN HEXANE (1) AND WATER (3); AND HYDROQUINOL IN HEXANE (2)
(18, 23)
log ε
1/λ 20000 22000 24000 26000 28000 30000 32000 34000 36000 38000 40000 42000 44000 46000 48000 50000
ν 600 660 720 780 840 900 960 1020 1080 1140 1200 1260 1320 1380 1440 1500
λ 5000 4545 4166 3846 3571 3333 3125 2941 2778 2631 2500 2381 2272 2174 2083 2000

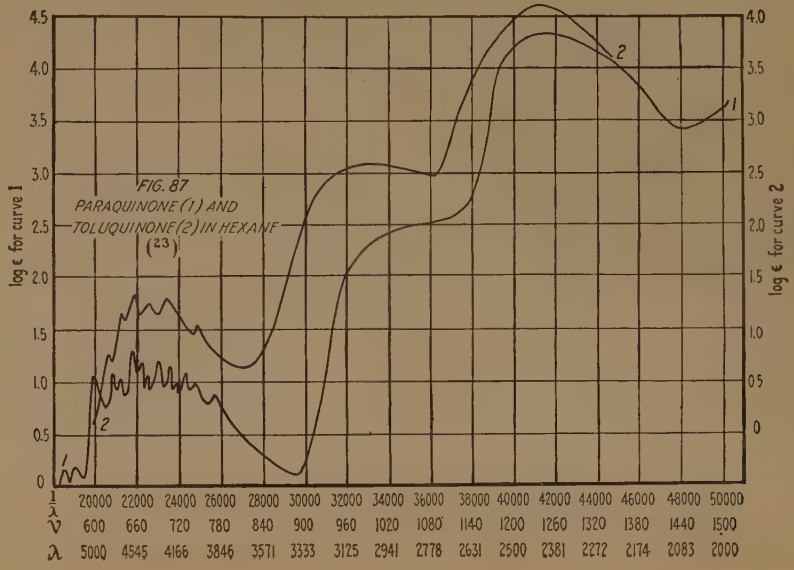


FIG. 87
PARAQUINONE (1) AND TOLUQUINONE (2) IN HEXANE
(23)
log ε for curve 1
log ε for curve 2
1/λ 20000 22000 24000 26000 28000 30000 32000 34000 36000 38000 40000 42000 44000 46000 48000 50000
ν 600 660 720 780 840 900 960 1020 1080 1140 1200 1260 1320 1380 1440 1500
λ 5000 4545 4166 3846 3571 3333 3125 2941 2778 2631 2500 2381 2272 2174 2083 2000

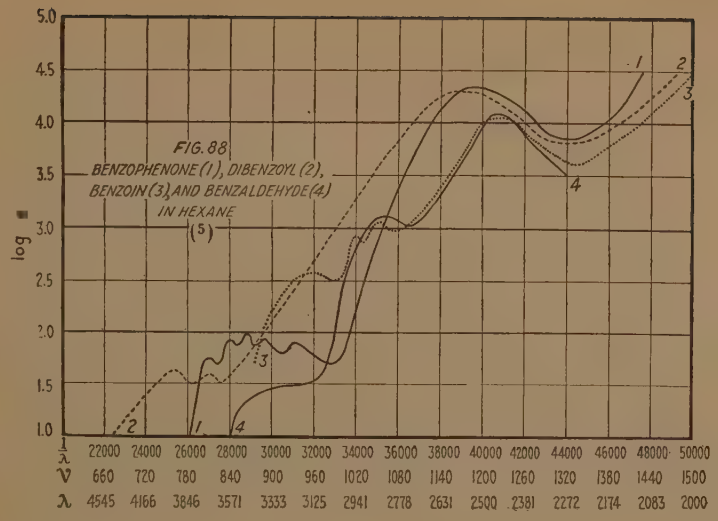


FIG. 88
BENZOPHENONE (1), DIBENZOYL (2), BENZOIN (3), AND BENZALDEHYDE (4) IN HEXANE
(5)

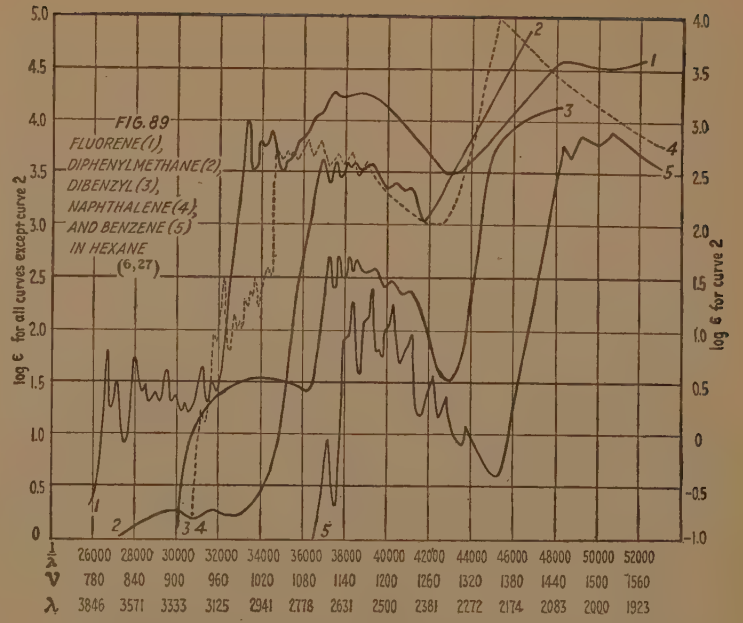


FIG. 89
FLUORENE (1), DIPHENYLMETHANE (2), DIBENZYL (3), NAPHTHALENE (4), AND BENZENE (5) IN HEXANE
(6, 27)

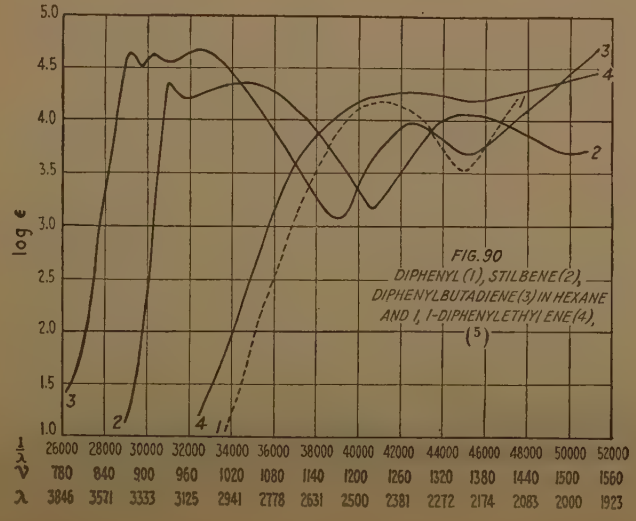


FIG. 90
DIPHENYL (1), STILBENE (2), DIPHENYLBUTADIENE (3) IN HEXANE AND 1, 1-DIPHENYLETHYLENE (4),
(5)

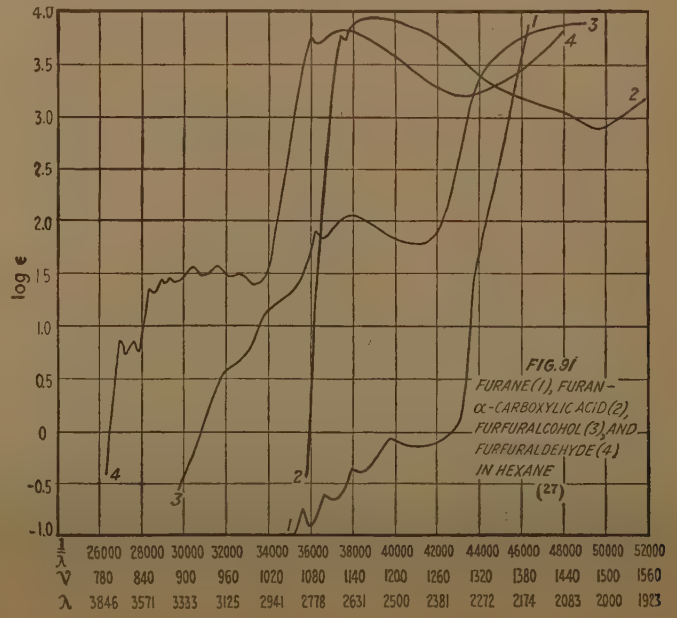


FIG. 91
FURANE (1), FURAN-α-CARBOXYLIC ACID (2), FURFURALCOHOL (3), AND FURFURALDEHYDE (4) IN HEXANE
(27)

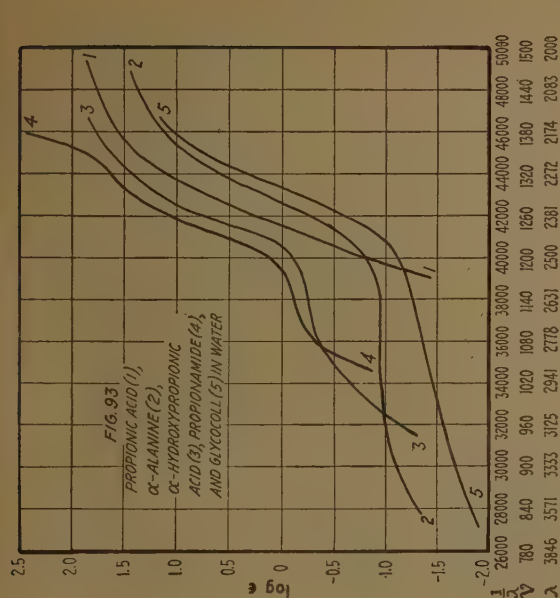


FIG. 93
PROPIONIC ACID (1), α-ALANINE (2), α-HYDROXYPROPIONIC ACID (3), PROPIONAMIDE (4), AND GLYCOCOLL (5) IN WATER
log ε
1/λ ν
λ

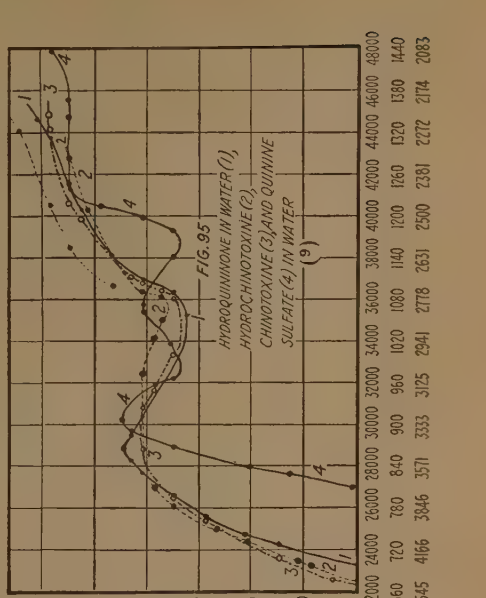
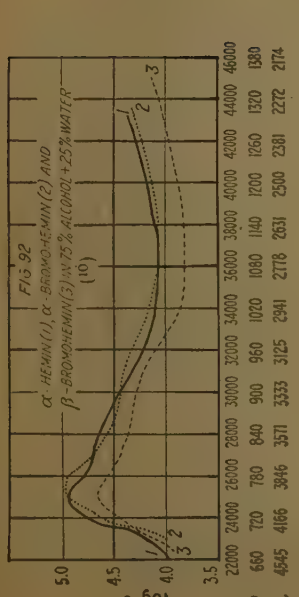


FIG. 95
HYDROQUININONE IN WATER (1), HYDROCHINOTOXINE (2), CHINOTOXINE (3) AND QUININE SULFATE (4) IN WATER (9)
log ε
1/λ ν
λ


α-HEMIN (1), α-BROMOHEMIN (2) AND β-BROMOHEMIN (3) IN 75% ALCOHOL + 25% WATER (10)
log ε
1/λ ν
λ

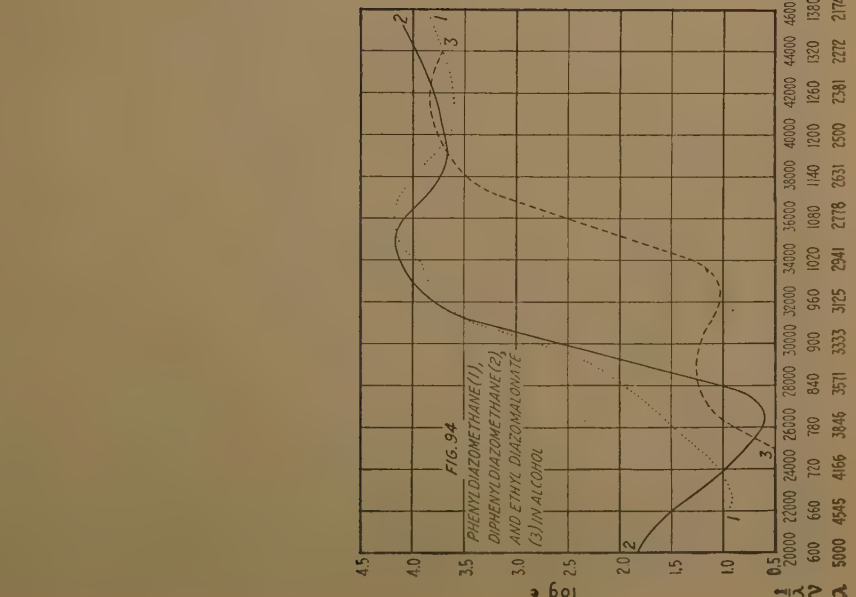


FIG. 94
PHENYLDIAZOMETHANE (1), DIPHENYLDIAZOMETHANE (2), AND ETHYL DIAZOMALONATE (3) IN ALCOHOL
log ε
1/λ ν
λ

SOLAR SPECTRUM

HAROLD D. BABCOCK AND W. S. ADAMS

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TABLE 1.—SOLAR SPECTRUM: TYPICAL LINES

An *R* placed after a wave-length (λ) indicates that it has been derived from Rowland's measurements (4) by means of Table 2; all other values of λ are derived from measurements made at Mount Wilson (3) in terms of internationally accepted standards. They all represent the value of λ in air at 15°C and a pressure of one normal atmosphere. Accidental errors exceeding 0.002 Å or 0.003 Å are improbable. The source of the line is generally that determined by Rowland. The spot intensities refer to typical spots; in "Spot δλ" are given the separations of the *n*-components in large spots, reduced to a common field strength (H = 3400 gauss). A line which is incompletely resolved from other nearby details of the spectrum *blends* with them, and is called a *blend*. Unit of λ = 1 Int. Å = 10^{-4} μ = 10^{-8} cm; of δλ = 10^{-3} Å = 10^{-11}cm.

λ	Source (4)	Intensity Sun (4)	Intensity Spot (3)	Spot δλ (3)	Group (1, 3, 5)	Temp. class (2)
3741.067	Ti	4				
48.273	Fe	10			*a*1	I*A*
52.417	Fe	3			*e*(?)	
56.943	Fe	4				IV
58.247	Fe	15			*b*1	II
60.538	Fe	4			*b*	III
69.996	Fe	4				IV
81.193	Fe	3				IV
90.659		1				
3804.016	Fe	3				
10.762	Fe, C	3				IV, —
21.188	Fe	4			*d*	IV
33.319	Fe	4				IV
42.057	Co	3				II
50.828	Fe	4			*b*	II
63.404	C	3N				
73.769	Fe	4				IV
85.521	Fe	4			*b*	III
91.936	Fe	4			*d*	V
3906.492	Fe	10		11	*a*1	I
06.756	Fe	4		12	*d*(?)	V
16.739	Fe	5	5	10	*b*	IV
20.271	Fe	10	8	12	*a*1	I
24.535	Ti	4	4	9	*a*1	II
37.339	Fe	3	3	14	*b*	IV
49.963	Fe	5	5	10	*b*	III
60.288	Fe	4	3	7		
71.334	Fe	5	5	8	*b*	III
77.752	Fe	6	5	14	*b*4	III
95.992	Fe	3	3	5	*b*	IV
4007.281	Fe	3	2	6	*b*	IV
20.907	Co	3	3	10		I
29.647	Fe-Zr	5	4	14		
40.649	Fe	3	3	8	*e*	

TABLE 1.—(*Continued*)

λ	Source (4)	Intensity Sun (4)	Intensity Spot (3)	Spot δλ (3)	Group (1, 3, 5)	Temp. class (2)
4053.273	Fe	2	2	12		
62.451	Fe	5	5	10	*b*	III
70.778	Fe	4	3	11		III
71.751	Fe	15	15	7	*b*1	II
95.983	Fe	3	3	8	*d*(?)	IV
4104.135*	Fe	5	5	17	*d*	V
14.453	Fe	4	4	10	*b*	IV
25.888	Fe	3	2	19		
36.530	Fe	4	4	4	*d*	
39.939	Fe	6	7	9	*a*	II*A*
54.507	Fe	4	4	12	*b*	III
54.815	Fe	4	4	17	*d*	IV
67.279	Mg(?)	8	6	13		
75.645	Fe	5	5	9	*b*	III
84.902†	Fe, Cr	4	4	13	*b*	III, III
95.342	Fe	5	5	13	*d*	IV
4202.042	Fe	8	9	10	*b*1	I
07.135	Fe	3	3	10	*b*	IV
08.612	Fe	3	3	10	*d*(?)	V
20.349	Fe	3	3	9	*b*	IV
22.223	Fe	5	6	11	*d*	III
33.613	Fe	6	8	10	*d*5	III
46.838	Sc+	5	4	8		IV*A*
57.663	Mn	2	3	15		II
65.268	Fe	2	2	13		
79.492	Fe	2	2	6		
82.413	Fe	5	6	14	*b*1	III
83.016	Ca	4	7	8		I
91.475	Fe	2	3	19	*a*3	I*A*
4302.540	Ca	4	7	12		I
18.660	Ca,Mn(?	4	6	16		I, —
26.764	Fe	2	2	11		
27.112	Fe	3	2	16	*b*	V
37.056	Fe	5	7	9	*b*3	II
38.273	Fe	1	1	9	*b*	
51.556	Fe	2	2	13	*b*	IV
52.745	Fe	4	6	18	*b*3	III
65.906	Fe	2	2	10		
69.781	Fe	4	4	19	*b*3	III
73.570	Fe	2	2	13		
75.946	Fe	6	10	14	*a*3	I
83.559	Fe	15	15	13	*b*1	II
88.416	Fe	3	3	22	*d*(?)	IV
4404.763	Fe	10	10	14	*b*1	II
15.137	Fe	8	8	15	*b*1	II
16.829	Fe+	2	0	11		
25.446	Ca	4	6	7		I
27.319	Fe	5	9	16	*a*3	I
35.158	Fe	2	4	14	*a*	II*A*
43.203	Fe	3	3	9	*b*3	III
54.390	Fe	3	4	13	*b*3	III
61.662	Fe	4	7	14	*a*3	I*B*
69.385	Fe	4	4	19	*d*	IV

TABLE 1.—(*Continued*)

λ	Source (4)	Intensity Sun (4)	Intensity Spot (3)	Spot δλ (3)	Group (1, 3, 5)	Temp. class (2)
4481.618*	Fe	1	1	35		
84.229	Fe	4	4	17	*d*	IV
85.685	Fe	3	3	36	*e*(?)	IV
94.575	Fe	6	8	15	*c*4	III
4502.225	Mn	2	2	28		III
12.745	Ti	3	6	25	*a*1	II
17.536	Fe	3	3	36		
34.788	Ti	4	6	18	*a*1	II
47.856	Fe	3	4	18		
63.767	Ti+	4	3	17		V*E*
71.104	Mg	5	8	19		
78.562	Ca	3	7	10		II
89.955	Ti+	3	2	23		
4602.951	Fe	6	8	22	*b*	I*B*(?)
07.655	Fe	4	4	14	*d*	V
17.280	Ti	3	5	20	*a*1	II
25.054	Fe	5	6	41	*d*	IV
30.130	Fe	4	4	26		
38.019	Fe	4	4	31	*d*(?)	IV
47.445	Fe	4	6	21	*b*	IV
78.857	Fe	6	6	22		V
4704.956‡	Fe	4	4	99		
22.165	Zn	3	1	60		
33.598	Fe	4	6	18	*b*	I*B*(?)
41.537	Fe	3	3	27	*b*	V
72.824	Fe	4	5	23	*b*	III
89.660	Fe	3	3	25	*b*	V
4802.888	Fe	2	1	31		
10.539	Zn	3	1	36		
24.143	Fe, Cr+	3	2	48		
32.721	Fe	3	2	25		
40.886	Ti	3	6	20	*a*1	I
48.254	Cr+	2	00	26		
59.749	Fe	4	6		*c*5	III
66.278	Ni	2	1	46		III
85.436	Fe	3	2	21	*d*	V
4904.420		3	2			
09.390	Fe	2	2	44		
17.237	Fe	2	2	60		
24.778	Fe	3	4	31	*b*	V
27.874	Fe	2	1	46		
30.313	Fe	2	2	31		
37.350	Ni(?)	3	1	55		III
38.179	Fe	2	2	15	*d*	
39.244	Fe	2	2	32	*d*(?)	
46.397	Fe	3	3	43	*d*	IV
67.905	Fe	3	2		*e*	
69.924	Fe	3	2			
94.139	Fe	3	6	27	*a*	I*B*
98.232	Ni	1	00	56		III
5005.720	Fe	4	4	35	*d*	V
10.944	Ni	0	0	46		
20.033	Ti	2	6	30	*a*1	II
24.852	Ti	3	7	17	*a*1	II
25.568	Ti	1	3	34		III
28.135	Fe	2	2	24		V
39.966	Ti	3	5	22	*a*1	I
49.829	Fe	6	8	28	*a*	III
60.076	Fe	3	6	37	*a*	
74.755	Fe	5	4	33	*e*	V
81.121	Ni	3	3	31		III

TABLE 1.—(*Continued*)

λ	Source (4)	Intensity Sun (4)	Intensity Spot (3)	Spot δλ (3)	Group (1, 3, 5)	Temp. class (2)
5082.351	Ni	2	0	40		
99.938	Ni	2	2	50		V
5110.409	Fe	5	9		*a*	I*B*
23.732	Fe	3	3		*a*	I*B*
31.478§	Fe	2	1	126	*a*	
41.748	Fe	3	5	34		
50.854	Fe	4	7		*a*	I*B*
59.065	Fe	2	2	42		
71.612	Fe	6	8		*a*	II
85.910	Ti	2	1	38		
91.467	Fe	4	5		*d*	IV
94.951	Fe	4	7		*a*	I*B*
97.578	Fe+	2	1	28		
5210.394	Ti	3	6	40	*a*1	I
25.535‖	Fe	2	3	131	*a*	I*A*
29.862	Fe	4	4	51	*d*	V
42.501	Fe	2	2	38	*a*	
50.218	Fe	2	2	182	*a*	I*A*
50.656	Fe	3	4	60	*b*	IV
63.316	Fe	4	4	65	*d*	V
73.172	Fe	3	3	54	*d*	
81.800	Fe	5	8	47	*d*	
88.533	Fe	2	2	44		
97.387	Cr	2	4	45		II
5302.308	Fe	5	6	57	*d*	V
07.370	Fe	3	5	46	*a*	III(?)
22.051	Fe	3	3	28	*b*(?)	
29.149	Cr	3	5	75		II
36.795	Ti+, −	4	3	58		V*E*, −
45.809	Cr	5	10	44		I
49.471	Ca	4	6	40		III
64.883	Fe	5	5	30	*e*	V
67.478	Fe	6	7	39	*e*	V
69.976	Fe	6	6	40	*e*	V
83.381	Fe	6	6	42	*e*	V
89.488	Fe	3	3	54		
93.178	Fe	5	6	63	*d*5	IV
97.143	Fe	7	14	49	*a*4	I*B*
5410.920	Fe	4	4	42	*e*	V
15.211	Fe-V	5	5	43	*e*	V, −
24.081	Fe	6	6	46	*e*	V
34.536	Fe	5	8	10	*a*4	I*B*
36.304	Fe	1	1	84	*b*(?)	
45.055	Fe	4	4	49	*e*	V
62.971	Fe	3	3	40	*e*	
66.407	Fe	3	3	50	*d*	
73.911	Fe	3	3	65	*d*	
80.867	Fe	1	1	96	*d*	
87.756	Fe	3	4	58		
97.528¶	Fe	5	13	222	*a*3	I*B*
5501.478	Fe	5	12	144	*a*3	I*B*
06.793**	Fe	5	12	146	*a*3	I*B*
12.991	Ca	4	8	40		III
34.849		2	1	27		
54.902	Fe	3	2	75	*e*	
62.718	Fe	2	2	96		
76.101	Fe	4	4	0	*d*5	IV
81.981	Ca	4	8	54		III
88.766	Ca	6	10	39		III
90.128	Ca	3	7	49		III
93.748	Ni	0	00	46		III

TABLE 1.—(*Continued*)

λ	Source (4)	Intensity		Spot δλ (3)	Group (1, 3, 5)	Temp. class (2)
		Sun (4)	Spot (3)			
5601.288	Ca	3	6	52		III
14.784	Ni	0	00	60		V
18.645	Fe	1	1	81	*d*	
24.033	Fe	1	1	48	*d*5	
33.955	Fe	3	3	53	*d*	
38.274	Fe	3	3	52	*d*5	V
41.450	Fe	2	2	52	*d*	
50.696	Fe	1	0	78		
55.502	Fe	2	2	58	*d*	V
62.527	Fe	4	3	51	*d*	V
67.526	Fe	2	2	110	*e*(?)	
79.034	Fe	3	3	84	*e*(?)	
82.650	Na	5	10	40		
84.497	Si	3	1	60		
88.220	Na	6	12	43		
90.435	Si	3	1	86		
5701.113	Si	1	00	98		
01.559	Fe	4	5	50	*e*(?)	III(?)
08.408	Si	3N	00	73		
11.098	Mg	6	6	43		
17.844	Fe	4	4	41	*d*	
31.775	Fe	4	3	101	*d*	
52.043	Fe	4	4	79	*e*(?)	
54.669	Ni	5	6	77		II
63.005	Fe	6	6	55	*d*	V
72.152	Si	3	0	53		
75.091	Fe	4	4	94	*d*	
87.930	Cr	4	9	63		III
93.926	Fe	2	2	104	*d*(?)	
5806.736	Fe	5	5	58	*e*(?)	
09.228	Fe	4	4	70	*d*	
16.384	Fe	5	5	44		
48.126	Fe	3	2	88	*d*	
52.232	Fe	3	4	80		
53.690	Ba+	5	9	72		III
62.371	Fe	6	6	59	*e*	V
66.464	Ti	3	10	49	*a*1	II
89.977	Na	30	100			I
92.885	Ni	4	4	50		II
95.943	Na	20	60			I
5905.684	Fe	4	3	34	*d*	V
16.261††	Fe	3	5	80		
27.801	Fe	2	2	28	*e*(?)	
34.669	Fe	5	5	57	*d*	V
48.552	Si	6	2	54		
56.709	Fe	4	10	32	*b*	
75.356	Fe	3	3	46	*b*4	
83.693	Fe	5	5	62	*d*	V
84.830	Fe	6	6	62	*e*	IV
6003.027	Fe	6	6	98	*d*	V
07.973	Fe	4	4	89	*e*	
13.503	Mn	6	11	155		III
16.653	Mn	6	12	192		III
21.808	Mn	6	12	106		III
27.064	Fe	4	4	64	*b*4	V
39.745*R*	V	0	6	135		I
42.108	Fe	3	2	38	*e*	V
56.018	Fe	5	5	50	*e*	V
58.177*R*	V	000N *d*(?)	3	330		II*A*
65.499	Fe	7	8	28	*b*4	III

TABLE 1.—(*Continued*)

λ	Source (4)	Intensity		Spot δλ (3)	Group (1, 3, 5)	Temp. class (2)
		Sun (4)	Spot (3)			
6078.504	Fe	5	5	81	*e*	V
81.458*R*	V	0	7	145		I
82.723	Fe	1	1	173	*b*(?)	
90.222	Ti, V	2	8	59		−, I
96.675	Fe	3	3	127	*d*	
6102.188	Fe	6	5	109	*e*	V
02.733	Ca	9	25	179		II
08.130	Ni	6	7	95		II
11.666*R*	V	0*d*(?)	10	188		II
19.535*R*	V	1	8	121		I
22.231	Ca	10	30	48		II
27.918	Fe	3	3	51	*b*	
35.375*R*	V	00N	8	188		
36.631	Fe	8	10	35	*b*4	III
37.709	Fe	7	9	98	*b*4	III
50.156*R*	V	0N *d*(?)	12	154		I
57.739	Fe	5	6	198	*b*4	V
61.302	Ca	4	9	124		III
62.185	Ca	15	35	166		II
66.446	Ca	5	9	79		III
73.348	Fe	5	4	236	*b*4	III
80.216	Fe	5	7	45	*b*(?)	
91.577	Fe	9	9	69	*b*4	II
99.195*R*	V	0	8	178		I
6200.327	Fe	6	8	124	*b*4	IV
13.443	Fe	6	6	237	*b*4	III
13.877*R*	V	000	5	149		I
19.294	Fe	6	8	160	*b*4	III
24.512*R*	V	000	5	146		I
32.655	Fe	3	4	275	*d*	V
42.853*R*	V	000	5	184		I
46.333	Fe	8	7	148	*d*5	V
51.846*R*	V	00	7	164		I
52.571	Fe	7	9	67	*b*	III
58.368*R*	V	000N	0	149		II*A*
61.299*R*	V	0000	000	196		II*A*
65.148	Fe	5	8	152	*b*4	III
68.878*R*	V	000N	4	176		II*A*
70.237	Fe	3	3	31	*b*	
85.182*R*	V	00N	6	154		I
92.828*R*	V	000	4	187		I
96.513*R*	V	0000	4	160		I
97.808	Fe	3	8	69	*b*4	III
6301.517	Fe	7	1	148	*d*5	IV
14.676	Ni	4	5	115		II
15.822	Fe	1	2	108		
18.035‡‡	Fe	6	8	40	*b*4	III
22.701	Fe	4	6	145	*b*	III
35.345‡‡	Fe	6	10	61	*b*4	III
36.837‡‡	Fe	7	7	204	*d*5	V
55.043	Fe	4	6	114	*b*	III
58.695	Fe	6	8	176	*a*	I*A*
80.756	Fe	4	3	33	*b*	V
93.620‡‡	Fe	7	8	36	*b*4	III
6400.328	Fe	2	4	147	*d*5	III
08.033‡‡	Fe	5	7	60	*d*	V
11.665	Fe	7	9	44	*d*5	IV
21.367	Fe	7	10	162	*b*	III
30.863	Fe	5	8	140	*b*4	III
39.090	Ca	8	12	33		II

TABLE 1.—(*Continued*)

λ	Source (4)	Intensity Sun (4)	Intensity Spot (3)	Spot δλ (3)	Group (1, 3, 5)	Temp. class (2)
6449.827	Ca	6	11	48		II
55.613	Ca	2	8	45		II
71.676	Ca	5	10	149		II
81.886	Fe	3	4	144	*b*	
93.796	Ca	6	12	48		II
95.001	Fe	8	9	86	*b*4	II
96.480	Fe	2	2	97	*d*	
96.916	Ba+	4	6	52		
99.663	Ca	4	8	71		II
6546.260	Fe-Ti	6	8	48	*b*4, *a*4	III, III
69.232	Fe	5	4	122		V
92.934	Fe	6	6	62	*b*4	III
93.892	Fe	4	5	84	*b*4	IV
6609.126	Fe	3	4		*b*	IV
43.648	Ni	5	5			I
63.455	Fe	3	4		*b*	IV
78.007	Fe	5	5		*b*4	III
6717.697	Ca	5	8			III
50.173	Fe	3	3		*b*	IV
67.793	Ni	4	4			I
6810.276	Fe	4	2			
28.612	Fe	2	2		*d*(?)	V
41.356	Fe	3	3		*d*(?)	V
43.672	Fe	3	2		*d*(?)	V
55.183	Fe	3	2		*d*(?)	V

TABLE 2.—CORRECTIONS FOR ROWLAND'S VALUES OF λ

Rowland's value exceeds the International value (*i.e.*, system of standards adopted in 1922) by an amount Δ which varies with λ.§§ Unit of λ = 100 Å = 10^{-6} cm; of Δ = 0.001 Å = 10^{-11} cm.

λ	38	40	42	44	46	48	49	50	51	52	53	54
Δ	137	149	158	158	173	184	177	174	169	164	172	200
λ	55	56	58	59	60	61	62	63	64	65	66	68
Δ	204	216	211	212	214	206	204	204	204	213	227	242

TABLE 3.—CORRECTIONS FOR 1928 INTERNATIONAL STANDARDS (7)

Each λ in Table 1 is too great by an amount C which varies with λ. Error in C is probably < 0.001A. Unit of λ = 100 Å = 10^{-6} cm; of C = 0.001 Å = 10^{-11} cm.

λ	37.5	39.5	40.5	41.5	42.5	43.5	45	46	47	49
C	1.5	2.0	2.0	2.0	2.0	2.0	2.6	3.1	3.0	2.8
λ	51	55	57	59	60	62	64	66	67	
C	2.6	2.3	3.0	3.8	4.7	6.5	8.4	10.2	11.2	

* Blend in spot. ** Complex in spot.
† Fe predominant. †† Probably blend in spot.
‡ Blend with complex line in spot. ‡‡ Components blended in spot.
§ Doubtful. ‖ Complex in spot. §§ *See also* (6).
¶ Line complex; δλ is for outer *n*-components.

LITERATURE

(For a key to the periodicals see end of volume)

(1) Gale and Adams, *21*, **35**: 10; 12. (2) King, *21*, **37**: 239; 13. **39**: 139; 14. **56**: 318; 22. (3) Mount Wilson Obs., Pasadena, Calif., *0*. (4) Rowland, *21*, **1**: 29, 131, 222, 295, 377; 95. **2**: 45, 109, 188, 306, 360; 95. **3**; 141, 201, 356; 96. (5) St. John and Ware, *21*, **39**; 5; 14. (6) St. John *et al.*, *152*, **No. 396**; 28. (7) Comm. Report., *538*, **3**: 93; 28.

UNIDENTIFIED LINES AND BANDS IN CELESTIAL SPECTRA

F. E. BAXANDALL

In the following tables, only the stronger of the unidentified lines are given; others will be found in the articles quoted.

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TABLE 1.—CELESTIAL SOURCES OF UNIDENTIFIED LINES
For bands, *v.* Table 3

Sym. = symbol by which the source is indicated in Table 2; Scale max. = maximum of the intensity scale adopted by the authority indicated in the Lit. column; Min. included = lowest intensity, by that authority, which is included in Table 2; No. = number of lines from that source which is included in Table 2; they lie between $\lambda_{min.}$ and $\lambda_{max.}$.

Unit of λ = 1 Å = 10^{-8} cm.

Source	Sym.	Lit.	Scale max.	Min. included	No.	$\lambda_{min.}$	$\lambda_{max.}$
Aurora	A	(3, 28, 34)			3	5577	5578
Corona	Cor	(8)*	30	4	13	3328	6374
Chromosphere	Chr	(11)	100	3	48	3231	5780
		(16)	10	3			
		(21)	100	2			
		(10)	80	3			
Fraunhofer spectrum	Fra	(7)	2	1	31	3033	9638
		(18)					
		(25)	40	4			

TABLE 1.—(*Continued*)

Source	Sym.	Lit.	Scale max.	Min. included	No.	$\lambda_{min.}$	$\lambda_{max.}$
Planets	Pla	(27)			7	5093	6677
Nebulae	Neb	(37)	360	10	17	3426	6583
Nova Aquilae No. 3	NoA	(17)			1	4603	4603
Nova Geminorum No. 2	NoG	(2, 31)	8	5	2	4610	4639
Nova Persei	NoP	(14)	10	3	5	3868	4720
Wolf-Rayet stars	W-R	(23)	50	3	29	3414	5304
		(37)†	100	15			
v Sagittarii	Sag	(24)	4	2	5	3938	4278
36 τ^9 Eridani	Eri	(33)	50	2	5	3954	4621
R. Aquarii	RAq	(19)			2	4658	4701
θ Aurigae	θAu	(15)	10	3	5	3954	4376
α Canum Venaticorum	CaV	(5)			6	3983	4815
η Carinae	Car	(22)	10	3	13	4244	4889
o Ceti	Cet	(1)			24	3852	4838
		(12)					
		(32)	90	4			
α Cygni	Cyg	(29)	10	3	25	3020	4876
		(35)					
		(38)	5	2			
		(39)	4	3			
H. P. 1311 (A. G. C. 8631)	HP	(9)			2	4059	4606
ε Ursae Majoris	UMa	(30)	10	3	5	3911	4275

* A summary of records of many observers. The λ's are probable values as derived from the collective records. Scale max. of no observer exceeds 30. Every unidentified line recorded by any observer as of intensity ≥ 4 is included in Table 2.

† The record used is the spectrum of the nucleus of planetary nebula B. D. + 30°, 3639, which contains almost all the lines of the Wolf-Rayet stars more sharply defined than in the Wolf-Rayet stars themselves.

TABLE 2.—UNIDENTIFIED LINES IN CELESTIAL SPECTRA

Only the stronger lines in the spectra of the sources listed in Table 1 are given. The symbol (*v.* Table 1) indicating the source is followed by a number indicating the authority (*v.* Lit.). Absorption lines are indicated by an *a* preceding the value of λ; values in { probably refer to the same line. The wave-lengths of lines of *o* Ceti recorded by Stebbins [32] and by Adams and Joy [1] have here been corrected for the mean velocity shift. For maximum of intensity scale, number of lines for each source, etc., *v.* Table 1. Sym. = symbol of the source, *I* = intensity, λ = wave-length. Unit of λ = 1 Int. Å = 10^{-8} cm (for reduction to Rowland's scale, *v.* Table 4).

λ	Sym.	*I*	λ	Sym.	*I*	λ	Sym.	*I*	λ	Sym.	*I*
a 3020.2	Cyg [39]	3	3643	Cor [8]	5	*a* 4128.7	UMa [30]	3	4561.97	Cet [12]	
a 3033.41	Fra [25]	5	3687	W-R [23]	4	*a* 4132.4	UMa [30]	5	4567	Cor [8]	6
a 3035.73	Fra [25]	5	3726.15*	Neb [37]	50	4137.3	Chr [16]	3	4583.90§	Cet [12]	
a 3038.8	Cyg [39]	3	3728.90*	Neb [37]	30	4138.64	Cet [12]		4586	Cor [8]	4
a 3047.7	Cyg [39]	3	3734	W-R [23]	3	4143.11	Chr [11]	3	4597.72	Chr [21]	2
a 3050.11	Fra [25]	4	*a* 3748.60	Cyg [38]	3	4155.2	W-R [37]	50	4600.6	Chr [16]	3
a 3053.41	Fra [25]	7	3769	W-R [23]	3	4156.3	Chr [16]	3	4603.7	NoA [17]	
a 3059.52	Cyg [39]	3	3769.75	Cyg [38]	3	*a* 4159.19	Fra [25]	5	{4606**	HP [9]	12
a 3096.45	Cyg [39]	3	3813.5	W-R [23]	3	4163.6	W-R [37]	50	{4608**	W-R [23]	3
a 3125.27	Fra [25]	5	3852.21	Cet [32]	4	4165.87	Cet [12]		{4610**	NoG [2]	5
a 3177.51	Cyg [39]	3	*a* 3859.95	Cyg [29]	3	*a* 4184.00	Fra [25]	4	4615.2	Chr [16]	3
a 3231.32	Chr [10]	3	*a* 3867.20	Chr [10]	3	*a* 4188.73	Fra [25]	4	*a* 4621.72	Eri [33]	2
a 3236.15	Chr [10]	3	{3868	NoP [14]	10	{*a* 4190.99	Eri [33]	2	4622	W-R [23]	10
a 3245.97	Fra [25]	4	{3868.65	Neb [37]	70	{*a* 4191.6	θAu [15]	3	4633.54	Cet [12]	
a 3251.92	Fra [25]	4	*a* 3911.25	UMa [30]	3	*a* 4198.24	Fra [25]	4	4634.76	Cet [12]	
a 3255	Cyg [38]	2	*a* 3936.90	Chr [10]	3	{*a* 4200.5	Sag [24]	2	{4636††	NoP [14]	3
a 3258	Cyg [38]	3	3938.05	Chr [16]	3	{*a* 4200.5	θAu [15]	3	{4639.0††	NoG [31]	
a 3261.62	Fra [25]	4	3938.19	Cet [32]	8	{*a* 4200.96	Eri [33]	4	4639.08	Cet [12]	
a 3281.21	Cyg [38]	3	{*a* 3938.40	Fra [25]	4	4229.4	W-R [37]	15	4658.2	RAq [19]	
a 3285.60	Cyg [38]	2	{*a* 3938.45	Cyg [29]	3	4231.2	Cor [8]	8	4666	W-R [37]	40
a 3288.60	Chr [10]	3	{*a* 3938.45	UMa [30]	3	{4233.15§	Cet [32]	12	4669.44	Chr [21]	2
a 3289.44	Cyg [38]	2	{*a* 3938.60	Sag [24]	3	{4233.26§	Cet [12]		4698.72	Chr [11]	3
a 3308.81	Fra [25]	5	*a* 3945.05	Cyg [29]	3	4244.09	Car [22]	8	*a* 4699.33	Fra [25]	4
a 3324.06	Fra [25]	4	3952.15	Chr [16]	4	*a* 4275.4	UMa [30]	3	*a* 4700.16	Fra [25]	4
3328.1	Cor [8]	5	{*a* 3954.15	θAu [15]	4	4276.85	Car [22]	5	4701.4	RAq [19]	
a 3366.17	Chr [10]	3	{*a* 3954.40	Eri [33]	2	*a* 4278.40	Sag [24]	2	4711.4	Neb [37]	10
3388	Cor [8]	30	3967.51	Neb [37]	70	4287.29	Car [22]	10	4720	NoP [14]	6
a 3407.22	Cyg [38]	2	3967.58	Cet [32]	8	4291.48	Cet [12]		4728.17	Car [22]	5
3414	W-R [23]	5	3969.86†	NoP [14]	10	*a* 4301.10	Fra [25]	4	4739	W-R [23]	3
a 3416.11	Cyg [38]	2	*a* 3973.44	Chr [10]	4	4302.78	Chr [11]	3	4740.2	Neb [37]	20
3426.3	Neb [37]	20	*a* 3983.85	CaV [5]		*a* 4303.94	Fra [25]	4	4756.54	Cet [12]	
a 3438.99	Chr [10]	4	3986.75	Cor [8]	5	4316.64	Chr [21]	2	4757.3	Chr [16]	3
3445	Neb [37]	13	3991.15	Chr [16]	3	4325.6	W-R [37]	50	4761.8	Chr [16]	4
3455	Cor [8]	8	4006.82	Cet [32]	9	4342.58	Car [22]	4	4768.27	Chr [21]	2
a 3465.74	Cyg [38]	2	4021.45	Chr [16]	3	4343.09	Chr [21]	2	4786.2	W-R [37]	20
{*a* 3468.71	Cyg [38]	2	*a* 4024.45	Cyg [29]	3	4358.94	Car [22]	10	4801.15	Cet [12]	
{*a* 3468.77	Chr [10]	3	*a* 4032.96	Sag [24]	2	4359	Cor [8]	6	4810.8	Chr [16]	3
{*a* 3471.39	Chr [10]	3	*a* 4038	CaV [5]		{4363.20‖	Neb [37]	80	4814.60	Car [22]	5
{*a* 3471.47	Cyg [38]	2	*a* 4040.90	Chr [10]	3	{4364	NoP [14]	7	*a* 4815	CaV [5]	
a 3487.95	Chr [10]	3	*a* 4044.08	Sag [24]	2	4372.68	Cet [32]	9	4838.50	Cet [12]	
a 3493.44	Cyg [38]	3	4049	W-R [23]	4	{*a* 4376.8	θAu [15]	3	4849.15	Chr [21]	2
a 3513.93	Fra [25]	4	4056.55	W-R [37]	55	{*a* 4377.44	Eri [33]	2	*a* 4876.5	Cyg [35]	3
a 3561.67	Chr [10]	3	4059‡	HP [9]	10	4407.9	Chr [16]	3	4889.46	Car [22]	3
a 3570.27	Fra [25]	4	4068.62	Neb [37]	60	4413.87	Car [22]	8	4958.91‖	Neb [37]	200
a 3572.47	Fra [25]	4	4070	W-R [37]	55	4416.26¶	Car [22]	9	5006.84‖	Neb [37]	360
a 3573.74	Chr [10]	3	{*a* 4076	CaV [5]		4441.2	W-R [37]	40	*a* 5093	Pla [27]	
a 3576.32	Fra [25]	4	{*a* 4076.15	θAu [15]	3	4446.38	Chr [11]	3	5130.7	W-R [37]	25
a 3585.33	Cyg [38]	3	4076.22	Neb [37]	20	*a* 4448	CaV [5]		*a* 5210	Pla [27]	
3601.15	Cor [8]	15	4086	Cor [8]	6	4448.13	Cet [1]		5250.9	W-R [37]	20
3611	W-R [37]		4086.55	Chr [16]	3	4451.94	Car [22]	6	5272.4	W-R [37]	15
3631	W-R [23]	3	*a* 4105.05	Chr [10]	4	4456.89	Cet [12]		5299.8	Chr [16]	3
3640.5	W-R [23]	3	*a* 4109.35	Chr [10]	3	4457	W-R [37]	20	5302.9	Cor [8]	20
						4457.80	Car [22]	5	5304.8	W-R [37]	15
						4458.62	Cet [12]		5425.29	Chr [21]	4
						4462.1	Chr [16]	3	*a* 5428	Pla [27]	
						a 4465.6	W-R [37]		5477.00	Chr [11]	3
						4474.70	Car [22]	3	5490.71	Chr [21]	2
						4496.6	Chr [16]	3	5577.35	A [3]	
						4511.56	Cet [12]		5577.83	A [28]	
						a 4516	CaV [5]		5578.0	A [34]	
						4516.4	W-R [37]	50	5669.3	Chr [16]	3
						4518.30	Chr [21]	3	5755	Neb [37]	20
						4521.37	Cet [12]		*a* 5762	Pla [27]	
						4555	W-R [37]	20	5780.6	Chr [16]	4
						4559.70	Cet [12]		*a* 5973	Pla [27]	

λ	Sym.	I
a 6191	Pla (27)	
6302	Neb (37)	10
6374	Cor (8)	
6548.1‡‡	Neb (37)	70
6583.6‡‡	Neb (37)	110
a 6677	Pla (27)	
a 7165.57	Fra (18)	2
a 7691.58	Fra (18)	2
a 8648.41	Fra (18)	2
a 9095.01	Fra (7)	1
a 9255.87	Fra (7)	1
a 9415.07	Fra (7)	1
a 9556.11	Fra (7)	2
a 9638.45	Fra (7)	1

* Theoretically identified as *OII* lines (6).

† Much too strong to be due solely to H_ϵ.

‡ Described by Harvard observers as double, the more refrangible component being the wider and fainter.

§ In *o* Ceti the bright lines other than those of H are generally considered to be lines of low temperature, hence these lines can not be identified with the enhanced Fe lines at 4233.33 and 4583.90.

‖ Theoretically identified as *OIII* lines (6).

¶ Probably involves enhanced Fe lines 4417.00; all the other prominent enhanced Fe lines occur in *η* Carinae.

** Probably identical in origin and λ; broad and hazy; possibly, but not surely, identical with oxygen line 4609.40 which appears to behave differently from other O lines.

†† These two λ's, obtained from different records, probably refer to the same line; line is broad and diffuse, and occurred in the later stages of the Novae.

‡‡ As neighboring C line at 6577.5 does not appear in nebular spectra, 6583.6 is probably not the C line at 6583.0; it and 6548.1 are probably of gaseous origin, like the great majority of nebular lines of known origin. Both have been theoretically identified as *NII* lines (6).

Table 3.—Heads of Unidentified Bands

For additional information and list of possible bands in sun-spot spectra, *v.* (4). R indicates that the band extends from the head towards the red end of the spectrum, V towards the violet. Unit of λ = 1 Å = 10^{-8} cm.

λ		Source	Lit.
4313.2*	R	*o* Ceti	(32)
4395.4	V	R types	(26)
4409.2	V	R types	(26)
4640†	R	S types and R Cygni	(20, 36)
4713.0	R	*o* Ceti	(32)
4736.9‡	R	*α* Herculis	(32)
4752.8§	V	N types	(13)
4841.6	R	*o* Ceti	(32)
4855.3	V	132 Schjellerup, etc	(13)
4871.4	R	152 Schjellerup, etc	(13)
4890.1	V	N types	(13)
4891.9	V	R types	(26)
4900.9	R	78 Schjellerup, etc	(13)
4906	R	152 Schjellerup, etc	(13)
5438.1	R	*o* Ceti	(32)
5550†	R	R Cygni	(20, 36)
5721.2	R	115 Schjellerup, etc	(13)

* Not the hydrocarbon band 4314.

† Probably due to ZrO.

‡ Not the "Swan" band 4737.

§ Probably due to a C compound.

Table 4.—Conversion to Rowland's Scale

λ on International scale + C = λ on Rowland's scale. Unit of λ and C = 1 Å = 10^{-8} cm

Range of λ	C	Range of λ	C
2950 to 3125	0.12	5400 to 5500	0.21
3125 to 3250	0.13	5500 to 6050	0.22
3250 to 3450	0.14	6050 to 6500	0.21
3450 to 4150	0.15	6500 to 6570	0.22
4150 to 4350	0.16	6570 to 6750	0.23
4350 to 4550	0.17	6750 to 6850	0.24
4550 to 5125	0.18	6850 to 7000	0.25
5125 to 5300	0.17	7000 to 7200	0.26
5300 to 5325	0.18	7200 to 7400	0.27
5325 to 5375	0.19	7400 to 7700	0.28
5375 to 5400	0.20		

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(For a key to the periodicals see end of volume)

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LOW-TEMPERATURE LUMINESCENCE

E. L. Nichols and E. Merritt

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Luminescence at low temperatures (<1000°C) may be produced by light, X-rays, cathode rays, radioactive radiations, chemical reaction, or as a continuing after-effect of a luminescence due to any cause. That which persists for a time after the withdrawal of the exciting cause is generally called *phosphorescence;* that which exists during the excitation is often called *fluorescence,* but in this section that term is restricted to the cases in which the luminescence is produced by light, X-rays, or γ-rays.

Some substances can be caused to luminesce when pure, others only when they contain an activating impurity, generally a metal. The nature of the luminescence depends upon both the substance and the impurity, and its intensity varies rapidly as the concentration of the latter is increased, passing through a maximum and finally becoming zero while the concentration is still low. *Cf.* Table 8; *see also* (6).

Table 1.—Intensity of Luminescence

For variation with concentration, *see* Table 8

B_0 = brightness of luminescence immediately after withdrawal of exciting radiation. Its value depends upon the intensity and the spectral distribution of the exciting radiation, and the latter affects the ratio of the values of B_0 for any two substances. B_r = relative brightness of the luminescence when ozone is passed through the solutions at a fixed rate. f = fluid solution, s = solid. Unit of $B_0 = 1$ millilambert = 0.001 lambert; of B_r is arbitrary.

Chemiluminescence when ozone is passed through solutions of esculin ($C_{15}H_{16}O_9$) (14); (for N and P-vapor, *see* Table 9)

Solvent	B_r	Solvent	B_r
H_2O, Water	1	C_3H_6O, Acetone	3
CH_4O, Methyl alcohol	3	C_3H_8O, Propyl alcohol	5
C_2H_6O, Ethyl alcohol	5	$C_3H_8O_3$, Glycerol	0

Fluorescence excited by Fe-spark with light-filter transmitting the region between *ca.* $\lambda = 0.3\mu$ and $\lambda = 0.4\mu$ (22)

Substance			B_0
$C_{20}H_{12}O_5$	Fluorescein (4.2 to 5.2)	f	4.7
	Luciferin (14.5 to 16)	f	15.2
$C_{12}H_7NO_3$	Resorufin	f	3.0
	Rhodamine 6G (4.2 to 12)	f	8.1
	Rhodamine B	f	5.2
	Tetrachloroeosin	f	4.2
ZnS	Sidot blende (3.08 to 10.9)	s	7
Zn_2SiO_4	Willemite (synthetic) (12.5 to 14)	s	13.2
Zn_2SiO_4	Willemite (natural)	s	5.3
$Cd_3(PO_4)_2$	Cadmium phosphate	s	0.0182
	Uranium glass	s	7.31

Table 1.—(*Continued*)

Substance			B_0
$(NH_4)_2UO_2(SO_4)_2$	NH_4 uranyl sulfate	s	23.0
$UO_2(NO_3)_2.6H_2O$	Uranyl nitrate	s	6.61
$UO_2(C_2H_3O_2)_2$	Uranyl acetate	s	5.39
$PbUO_2(C_2H_3O_2)_4.4H_2O$	Pb uranyl acetate	s	3.75
CaS	Balmain's paint	s	1.26
$CaCO_3$	Calcite	s	0.132
$K_3UO_2F_5$	K uranyl fluoride	s	4.69
$K_2UO_2(SO_4)_2.2H_2O$	K uranyl sulfate	s	35.2
$KUO_2(NO_3)_3$	K uranyl nitrate	s	7.53
$Rb_2UO_2Cl_4.2\ H_2O$	Rb uranyl chloride	s	8.11
$CsUO_2(NO_3)_3$	Cs uranyl nitrate	s	5.71
$CsUO_2(C_2H_3O_2)_3$	Cs uranyl acetate	s	4.56

Table 2.—Wave-lengths (λ) of Crests of Bands: Photoluminescence

For ultra-violet luminescence of 128 organic compounds in alcoholic solution, *see* (19)

In some cases only the principal bands are here listed. C = concentration, parts by weight or fraction of normal (N); N = normal concentration; Hg-arc = Hg arc in quartz tube. Tabular values are λ_0. Solvent is ethyl alcohol (C_2H_5OH) unless otherwise indicated. Unit of $\lambda = 1$ Å $= 10^{-8}$ cm; $\Delta(1/\lambda) = \text{cm}^{-1}$.

C_6H_6, Benzene

$C = \frac{1}{2000}$; Zn-spark (8)
2599, 2635, 2679, 2754, 2827, 2910.

$C = \frac{1}{2000}$; Hg-arc (33)
2700, 2757, 2829, 2943.

$C = 0.05N$; $t = -193$°C; Hg-arc (18)
3390, 3460, 3520, 3570, 3650, 3710, 3800, 3850, 3970, 4020, 4130, 4190, 4290, 4350.

C_6H_6O, Phenol

$C = \frac{1}{2000}$; Zn-spark (8); 2776
$C = 0.05N$; $t = -193$°C; Hg-arc (18)
3510, 3610, 3710, 3830, 3960, 4080.

$C_6H_6O_2$, Hydroquinol

$C = \frac{1}{2000}$; Zn-spark (8); 3032

$C_6H_6O_2$, Resorcinol

C = (?); Hg-arc (33); 3000

C_6H_7N, Aniline

$C = \frac{1}{2000}$, Zn-spark (8); 3084
$C = 0.05N$; $t = -190$°C; Hg-arc (16, 17)
3720, 3830, 3960, 4110, 4240.

C_7H_5N, Benzonitrile

$C = 0.05N$; Hg-arc (16, 17)
3790, 3810, 3870, 3950, 4050, 4120, 4210, 4310, 4410, 4510.

$C_7H_6O_2$, Benzoic acid

$C = 0.05N$; Hg-arc (16, 17)
3660, 3790, 3910, 4050, 4160.

$C_7H_6O_3$, *p*-Hydroxybenzoic acid

$C = 0.05N$; Hg-arc (16, 17)
3790, 3920, 4050, 4210, 4330.

C_7H_8, Toluene

$C = \frac{1}{2000}$; Zn-spark (8)
2622, 2646, 2676, 2740, 2809, 2886.

$C = 0.05N$; $t = -193$°C; Hg-arc (18)
3460, 3580, 3650, 3800, 3890, 4060, 4120.

C_7H_8O, *o*-Cresol

$C = 0.05N$; $t = -193$°C; Hg-arc (18)
3530, 3630, 3740, 3850, 3970.

C_7H_8O, *m*-Cresol

3540, 3620, 3730, 3850, 3970, 4080.

C_7H_8O, *p*-Cresol

3630, 3730, 3850, 3980, 4110.

C_7H_9N, Benzylamine

$C = 0.05N$; $t = -190$°C; Hg-arc (16, 17)
3470, 3600, 3670, 3800, 3910.

$C_8H_6O_4$, *o*-Phthalic acid

C = (?); Hg-arc (33); 3100

C_8H_7N, *o*-Tolunitrile

$C = 0.05N$; $t = -190$°C; Hg-arc (16, 17)
3750, 3800, 3930, 4000, 4110, 4180, 4260.

TABLE 2.—(*Continued*)

C_8H_7N, *m*-Tolunitrile
3790, 3910, 3960, 4050, 4160, 4220, 4290, 4440, 4550, 4650.

C_8H_7N, *p*-Tolunitrile
3770, 3890, 3950, 4020, 4150, 4220, 4290, 4450, 4520, 4600.

$C_8H_8O_2$, Phenylacetic acid
$C = 0.05N$; $t = -190°C$; Hg-arc (16, 17)
3440, 3570, 3640, 3790, 3860.

$C_8H_8O_2$, *o*-Toluic acid
$C = 0.05N$; $t = -190°C$; Hg-arc (16, 17)
3670, 3790, 3920, 4040.

$C_8H_8O_2$, *m*-Toluic acid
3740, 3860, 4000, 4120, 4250.

$C_8H_8O_2$, *p*-Toluic acid
3730, 3840, 3980, 4100, 4240.

C_8H_{10}, *o*-Xylene
$C = \frac{1}{2}000$; Zn-spark (8)
2603, 2636, 2680, 2713, 2793, 2896, 2986, 3038, 3135.
$C = 0.05N$; $t = -193°C$; Hg-arc (18)
3480, 3560, 3610, 3670, 3790, 3830, 3900, 4000, 4070, 4130.

C_8H_{10}, *m*-Xylene
(8) 2685, 2715, 2802.
(18) 3540, 3610, 3670, 3730, 3820, 3880, 3970, 4090, 4160, 4230.

C_8H_{10}, *p*-Xylene
(8) 2681, 2739, 2801, 2865.
(18) 3550, 3650, 3700, 3770, 3890, 3950, 4010, 4120, 4190, 4270.

C_8H_{10}, Ethylbenzene
$C = 0.05N$; $t = -193°C$; Hg-arc (18)
3450, 3580, 3640, 3780, 3870, 4050, 4120.

$C_8H_{10}O$, *o*-Methylcresol
$C = 0.05N$; $t = -193°C$; Hg-arc (18)
3550, 3620, 3760, 3850.

$C_8H_{10}O$, *m*-Methylcresol
3570, 3660, 3770, 3900, 4000.

$C_8H_{10}O$, *p*-Methylcresol
3660, 3770, 3900, 4000, 4120.

$C_8H_{10}O$, Xylenol
$C = 0.05N$; Hg-arc (16, 17)
3570, 3660, 3780, 3890, 4010.

C_9H_7N, Quinoline
$C = \frac{1}{2}000$; Zn-spark (8); 3840

C_9H_{12}, Propylbenzene
$C = 0.05N$; $t = -193°C$; Hg-arc (18)
3440, 3580, 3650, 3790, 3890, 4050, 4130.

C_9H_{12}, Mesitylene
$C = \frac{1}{2}000$; Zn-spark (8)
2698, 2712, 2747, 2786, 2863, 2972.
$C = 0.05N$; $t = -190°C$; Hg-arc (16, 17)
3570, 3620, 3690, 3760, 3850, 3920, 4000.

C_9H_{12}, Pseudocumene
$C = 0.05N$; $t = -190°C$; Hg-arc (16, 17)
3560, 3650, 3770, 3880, 4000, 4120, 4270.

$C_{10}H_8$, Naphthalene
$C = \frac{1}{2}000$; Hg-arc (33)
3157, 3223, 3269, 3320, 3349, 3386, 3457, 3500, 3537.
$C = \frac{1}{2}000$; Zn-spark (8)
3000, 3046, 3098, 3142, 3190, 3235, 3292, 3340, 3386, 3447, 3498, 3558, 3627, 3654.

$C_{10}H_8O$, α-(β)-Naphthol
$C = \frac{1}{2}000$; Zn-spark (8)
λ_α = 3185, 3250, 3379; λ_β = 3274, 3348.

$C_{10}H_9N$, α-(β)-Naphthylamine
$C = \frac{1}{2}000$; Zn-spark (8)
λ_α = 3553; λ_β = 3579.

$C_{10}H_{14}$, Cymene
$C = 0.05N$; $t = -190°C$; Hg-arc (16, 17)
3530, 3640, 3730, 3850, 3970.

$C_{12}H_{10}$, Diphenyl
$C = \frac{1}{2}000$; Zn-spark (8)
2864, 2893, 2921, 2966, 3022, 3113, 3186, 3321.

$C_{12}H_{11}N$, Diphenylamine
$C = \frac{1}{2}000$; Zn-spark (8); 3158

$C_{13}H_{12}$, Diphenylmethane
$C = \frac{1}{2}000$; Zn-spark (8)
2650, 2684, 2742, 2815, 3736, 3924, 4144.

$C_{14}H_8O_5$, Purpurin in ethyl ether ($C_4H_{10}O$)
C = (?); sunlight (31); 5440

$C_{14}H_{10}$, Anthracene
$C = \frac{1}{2}000$; Hg-arc (33)
3857, 4000, 4300, 4357.
$C = \frac{1}{2}000$; Zn-spark (8)
3658, 3762, 3897, 4115, 4354.

$C_{14}H_{10}$, Phenanthrene
$C = \frac{1}{2}000$; Hg-arc (33)
3014, 3100, 3166, 3271, 3343, 3400, 3486, 3529, 3557, 3643, 3700, 3749, 3834, 3943, 4043, 4243, 4443.
$C = \frac{1}{2}000$; Zn-spark (8)
2971, 2995, 3065, 3154, 3231, 3302, 3382, 3439, 3494, 3545, 3614, 3733, 3797, 3926, 3992, 4134, 4229.

$C_{14}H_{10}O$, Anthranol
$C = \frac{1}{2}000$; Zn-spark (8)
2731, 2781, 2829, 2882, 2939, 2990, 3063, 3119, 3190, 3441, 3617, 3735, 3930, 4139.

$C_{15}H_{16}O_9$, Esculin
C = (?); white light (26); 4600

$C_{19}H_{16}$, Triphenylmethane
$C = \frac{1}{2}000$; Zn-spark (8)
2688, 2704, 2757, 2832, 3717, 3823, 4032, 4258.

$C_{20}H_8Br_4O_5$, Eosin in water
C = (?); white light (26); 5800

$C_{20}H_8I_4O_5$, Erythrosine in gelatin
C = (?); Hg-arc (32); 4150

$C_{20}H_{12}O_5$, Fluorescein in concentrated H_2SO_4
$C = \frac{1}{2}000$; Hg-arc (33)
3200, 4700, 5100.

$C_{20}H_{14}O_4$, Phenolphthalein
C = (?); Hg-arc (33); 3000

$C_{40}H_{50}N_4O_8S$, Quinine sulfate in water
C = (?); white light (26); 4370

$C_{40}H_{50}N_4O_8S$, Quinine sulfate
$C = \frac{1}{2}000$; Zn-spark (8); 3355

Cyanin in gelatin
C = (?); Hg-arc (32); 4000

$C_{13}H_8O_4$, 3, 6-Dihydroxyxanthone
C = (?); Hg-arc (33); 4200

Rhodamine in water
C = (?); white light (26); 5540

$Pt(CN)_2$ and double Pt-cyanides, Fe-spark gives same bands as cathode-rays (3), *see* Table 3.

UO_2SO_4 in water (13); C = (?)

4918.3	5133.9	5369.4	5626.8
	5160.2	5395.8	5654.0
	5910.1	6219.5	
	5938.8		

$UO_2(NO_3)_2$ in water (13); C = (?)
5069.6, 5301.5, 5554.6, 5832.9.

$UO_2(NH_4)_2(SO_4)_2$ in water (13); C = (?)

4912.6	5124.5	5355.4	5607.4
4934.7	5147.8	5380.1	5633.3
5881.1	6184.0		
5908.0	6215.7		

Al_2O_3, Ruby in sunlight (5)
−190°C (lines) 6918, 6932, 6976,* 6985,* 7006, 7036, group at 7060 to 7130.
+18°C (bands) 6590, 6690, 6760, 6790,* 6926, 6941, group† 7016, 7046, 7060,* 7130.*
+225°C (bands) 6610, 6945, 6960; 4 diffuse bands* at 7016 to 7130.

* Not recorded in extraordinary spectrum.
† Not recorded in ordinary spectrum.

$CaCO_3$, Calcite; Fe-spark (25); 2 sets of bands;* for each, $\Delta(1/\lambda)$ = 420 cm^{-1}.
5084, 5195, 5311, 5432, 5559, 5692, 5831, 5977, 6131, 6293, 6464.
5025, 5133, 5247, 5365, 5488, 5618, 5754, 5896, 6046, 6203, 6369, 6545.

* Same sets for CaO excited by H-flame (12), and in cathodoluminescence of CaO activated with Mn (34).

$NaUO_2(C_2H_3O_2)_3$, Sodium uranyl acetate in water (13).
C = (?); 6 sets of 5 bands; for each set, $\Delta\lambda^{-1}$ = *ca.* 851 cm^{-1}.

4732.5	4932.5	5148.6	5384.5
	4950.2	5167.8	5404.5
4762.3	4964.9	5184.9	5424.0
4769.2	4972.1	5192.2	5431.6
4785.8	4990.2		
4794.6	4999.2	5221.4	5463.5
5642.7	5663.4	5685.8	5694.6

$Na_2UO_2(SO_4)_2$ in water (13); C = (?)

4891.5	5101.2	5330.0	5578.5
	5125.4	5354.7	5604.6

TABLE 3.—WAVE-LENGTHS (λ) OF LINES AND OF CRESTS OF BANDS: CATHODOLUMINESCENCE

For effect of solvent upon wave-length of maximum brightness of solid solutions, *see* Fig. 1

B. P. = boiling point, *d* = diffuse, *e* = edge of band, *f* = fine, narrow band, *g* = gas or vapor, *m* = maximum, *n* = nebulous, *s* = strong, *w* = weak, *D* = very diffuse, *D′* = very, very diffuse, etc.; similarly for *S*, *S′*, *S″*, *W*, and *W′*. Tabular values are λ; bands unless lines are indicated. Unit of λ = 1 Å = 10^{-8} cm.

A (21) *g* at B. P. of H: 5607.4*S*, 5648.3

Phosphorescence (afterglow): 4750*s*, 5350*w*

Ca (15) *g* lines coincide with arc lines but differ in intensity

3179.50*w*	3181.43*W*	3630.87	3644.53	3706.18	3737.06*s*
3933.81*S′*	3957.22*W*	3968.63*S′*	3973.91	4108.60	4226.90*S″*
4240.61	4302.70*w*	4355.50*s*	4425.60	4435.17*s*	4435.88*w*
4455.00*S*	4456.10*w*	4527.35*s*	4581.77*w*	4586.22	4685.35
4878.38	5041.83*w*				

Cd (9, 20) *g* single line spectrum: 3260.17

TABLE 3.—(*Continued*)

Dy in Al_2O_3 [29] solid solution

4478	4500	4519*w*	4545	4571*s*	4601
4694*S*	4709*S*	4721*S*	4761*S*	4768*S*	4788*S*
4809*S*	4837*w*	4861*S'*	4895	4919*s*	4924*s*
4940	4950*s*	4970*S*	4991*w*	5544*w*	5652
5660	5690*w*	5741*w*	5770	5803*S*	5818*S*
5833*W*	5880*S*	5891*S*	5945*s*	5961	6545*W'*
6720*W*					

Dy in CaO [36] solid solution, concentration = 1 % Dy_2O_3

4540	4728	4748	4797*S*	4890*S*	5708
5830*	5848*S**	5958	6750*S*		

Dy in $CaWO_4$ [29] solid solution

4479	4546*s*	4620*W*	4690*D*	4739	4782*s*
4868*s*	5063*W*	5212*w*	5342*s*	5449*s*	5490*d*
5511	5606	5656	5690*s*	5747*S*	5787*s*
5816*s*	6022*W*	6450*W*	6588*sd*	6662*d*	

Er in CaO [36] solid solution, concentration = 1 % Er_2O_3

4040*S*	4085*S*	4095	4460	4520	4550*S*
4590*S*	5280*	5330*	5595		

Eu in Al_2O_3 [29] solid solution

5040*wn*	5438*d*	5584*d*	5509*sd*	5995*sd*	6158*Sd*
6304*d*	6588*d*	6930*sd*			

Eu in CaO [36] solid solution, concentration = 1 % Eu_2O_3

4160*S*	4195*S*	4245*S*	4260*S*	4330	4466
4490	4655	4685*S*	4755	5405	5895*S*
5930*S*	5970	6128*S*	6155*	6180*	6245*S*

Eu in $CaWO_4$ [29] solid solution; rose color

4100*e*	5350*m*	5720*e*	5901	5952*D*	6061*D*
6110*s*	6148*S*	6199	6545*D*		

Fe [15] *g* lines coincide with arc lines

3440.762	3441.155	3570.273	3581.349*s*	3609.008*w*	3618.919*w*
3631.605*w*	3647.988*w*	3680.069*W*	3687.610*W*	3705.708*w*	3720.084*S*
3722.729*w*	3727.778*W*	3735.014*s*	3737.281*s*	3745.717*s*	3748.408
3749.631	3758.375	3763.945*w*	3767.341*W*	3813.100*W*	3815.987*w*
3820.586	3824.591	3826.027	3834.364*w*	3840.580*W*	3856.524
3860.055*S*	3878.720	3886.434	3920.410*w*	3923.054*w*	3928.075*w*
3930.450*w*	4045.975*w*	4308.081*W*	4325.939*W*	4383.720	4404.927*W*

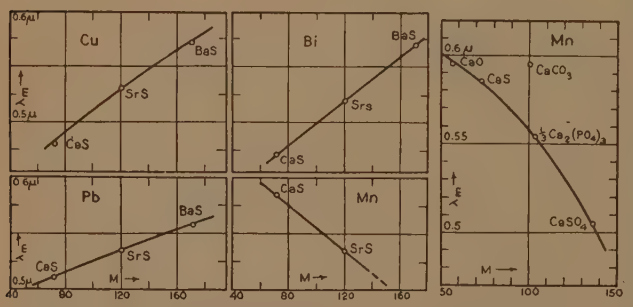

FIG. 1.—Wave-length (λ_m) of maximum intensity of cathodoluminescence of solid solutions: Effect of solvent [34].

In each section, the activating metal (Bi, Cu, Mn, or Pb), and at each point, the corresponding solvent is indicated. M = molecular weight of solvent.

Gd in CaO [36] solid solution, concentration = 1 %

3088.5*	3094.0*	3134.0†	3140.5*S*†	3144.0†	3147.0*S*
3153.0*S**	3155.5*	3158.5*S**			

Hg [9, 20] *g* single line spectrum: 2536.72

Mg [9, 20] *g* single line spectrum: 2852.22

N [21] *g* at B. P. of H: 5556*S*, 5617*s*, 5654

Phosphorescence (afterglow): 5231*s*

Na [39] *g* lines; those marked *N* are attributed to nitrogen

3052.9	3055.4	3073.9	3077.4	3078.9*w*	3092.3*s*
3128.9	3134.9	3149.0	3158.8	3163.9	3169.2*w*
3189.4	3213.6	3225.8*w*	3235.0	3257.9	3274.1
3285.4*s*	3302.8	3304.8	3318.2	3327.6	3371*s*
3533.3*s*	3536.5	3576	3582	3631.6*s*	3710.8

Na.—(*Continued*)

3754.8	3805.1	3882.6	3884.8	3894.0*Nw*	3896.6*N*
3898.8*N*	3901.3*N*	3903*N*	3905*N*	3907*N*	3908.7*N*
3914*Ns*	4236	4248*w*	4252*Nw*	4256*N*	4259
4262*Nw*	4265*Nw*	4268*Nw*	4270*Nw*	4271.5*Nw*	4273.0*Nw*
4278.2	4308.7*w*	4321.4	4324.7	4341.1	4344.0
4389.4	4392.8	4404.8*w*	4418.6*w*	4421.9	4448*w*
4454.5*w*	4481.5	4484.5	4490*w*	4493.8	4497.3
4541.3	4544.8	4664.7*s*	4668.4*s*	4710*w*	4748.3
4752.2	4862*w*	4979.3*s*	4983.5*s*	5149.2	5153.7
5221.0*w*					
Bands:	5700	5744	5792	5843	5894
5946	6000	6053	6112	6164	6218
6276	6328	6388	6455	6515	6565

Nd in Al_2O_3 [29] solid solution

3613*n*,	3634	3651*n*	3661*w*	3665*d*	3670*d*
3685*w*	3917*w*	3923*e*	3930*e*	3943*S*	4006*s*
4038*S*	4069*S*	4081*s*	4306*e*	4310*e*	4340*s*
4415*e*	4426*e*	4439*e*	4453*e*	4466*e*	4472*e*
4482*e*	4495*e*	4589*e*	4595*e*	4626*e*	4645*e*
4673*w*	4709*s*	4851	4884*S*	4913*s*	4948*w*
5305*S*	5505*s*	5672			

Nd in CaO [36] solid solution, concentration = 1 % Nd_2O_3

3920*S*	3980	4190*S*	4220*S*	4230*S*	4295*S*
4575*S*					

Nd in $CaWO_4$ [29] solid solution, continuous spectrum, blue

Pr in CaO [36] solid solution, concentration = 1 % Pr_2O_3

4875*S*	4940	5170	6045*S**	6065*S**	6150†
6200†	6260*S*	6340*S*			

Pr in $CaWO_4$ [29] solid solution

4756*D*	4874*S*	4989*d*	5092*D*	5189*D*	5284*D*
5324*S*	5412*d*	5495*wd*	5574*w*	5683*sd*	5748*Wd*
5773*Wd*	5940*d*	6034*s*	6100*D*	6194*s*	6278
6394	6500*S*	6540*wd*			

$Pt(CN)_2$ and double Pt-cyanides of Ba, Ca, K, K_2Ca, KLi, KNa, Mg, NH_4, Na, and Sr [3]. Positions of bands are same for all, but relative intensities differ; positions depend upon hydration.

Dehydrated salts:		4100	4300	4620
4740	5370	5780	6480	6560
Salts not dehydrated:		4140	4300	4610
4720	4920	5340	5760	5920	6370

Sa in Al_2O_3 [29] solid solution

4700*n*	4850*n*	5079*W*	5175*W*	5353*wd*	5440*w*
5465*w*	5550	5644*S*	5730*S*	5817*s*	5857*w*
5909	5990	6107*S*	6194*S'*	6230*f*	6265*S*
6387*w*	6505*w*	6618	6753		

Sa in CaO [36] solid solution, concentration = 1 % Sa_2O_3

5486	5561	5683*S*	5762*S*	6052*S**	6150*S**
6265	6605†	6740†			

Sa in $CaWO_4$ [29] solid solution

5272*e*	5300*m*	5460*e*	5545*d*	5628*s*	5689*d*
5885*d*	5952*S*	5994*S*	6050*S*	6072*S*	6124*d*
6368*d*	6420*S*	6460*S*	6544*d*	7100*w*	7900*W*

Tb in Al_2O_3 [29] solid solution

3532*W*	3543*n*	3565*n*	3591*n*	3611*n*	3646*w*
3653*w*	3660*w*	3685	3702*s*	3760*s*	3778*s*
3795*s*	3797	3812*S*	3828*S*	3847*s*	3853*s*
3889*S*	3906*S'*	3986*e*	4014	4029*S*	4099
4102*S*	4121*s*	4122*w*	4131*w*	4141*s*	4159*s*
4170*w*	4180	4191*S*	4212*s*	4229*S*	4230*S'*
4306	4330*S*	4369*S*	4392*S''*	4414*S'*	4437*S'*
4461*S*	4490*S*	4554	4600*S*	4606*S*	4664*w*
4743*s*	4767*s*	4788*s*	4813*w*	4832	4862*S*
4878*e*	5009	5018*S'*	5454*n*	5517*S*	5573*S'*
5807	5856	5886*w*	5920*s*	5989*n*	6264*s*

Tb in CaO [36] solid solution, concentration = 1 % Tb_2O_3

3770*S*	3787*S*	3805*S*	3880*S*	3900*S*	4180*S*
4190*S*	4200*S*	4210*S*	4350*S*	4370*S*	4395*S*
4855*S*	5425*S*	5495*S**	5521*S**	5550*S*	5843*S*
5878*S*	5955*S*	6017*S*	6330*S*		

Tb in $CaWO_4$ [29] solid solution

3720*W*	3762*w*	3789	3819	3853	4100
4140*s*	4168	4243*w*	4311*w*	4332*w*	4355*S*
4379	4398	4427	4563	4588	4707
4738	4759	4859*S*	4879*S*	4906*s*	4951*s*
4990*w*	5425*e*	5458*S'*	5491*S'*	5517*s*	5808
5839	5881*S*	5891*s*	5951	5979*W*	6168*s*
6214*S*	6257*s*	6293*d*	6412*d*	6456*d*	6542
6717*s*	6822*W*	7400*W*			

Zn [9, 20] *g* single line spectrum: 3075.99

* Overlaps the similarly marked adjacent band.

† Overlaps the similarly marked adjacent band.

TABLE 4.—WAVE-LENGTHS (λ) OF CRESTS OF BANDS: CHEMILUMINESCENCE

Certain chemical reactions proceeding at low temperatures give rise to luminescence. The bands recorded below are due to oxidation. *s*, *w* = strong, weak; *S*, *W* = very strong, very weak. Tabular values are; λ unit = 1 Å = 10^{-8} cm.

P, Phosphorus (7)

2381*W*	2387*W*	2398*s*	2454*s*	2458*S*	2474*S*
2507*W*	2517*W*	2531*W*	2544*W*	2579*W*	2587*W*
2613*W*	3339*W*				

For brightness and efficiency of luminescence of N saturated with P-vapor, *see* Table 9.

$C_6H_6O_3$, Pyrogallol (30); 4590 (width = 350 Å)

TABLE 5.—WAVE-LENGTHS (λ) OF CRESTS OF BANDS: LUMINESCENCE EXCITED BY FLAMES, X-RAYS, AND RADIATIONS FROM RADIOACTIVE SUBSTANCES

Fl, X, RR = excitation by flame, X-rays, radioactive radiations.

C, Diamond (30) RR: 4030, 4120, 5510

Cb_2O_5, Fl(23) two sets of bands: 4831, 5500, 6748; and 5020, 5747, 6196.

$BaPt(CN)_4$	RR (30)	5430 to 6040	wide crest
$BaPt(CN)_4$	X (2)	continuous spectrum	
$BaSO_4$	X (28)	3120 to 4760	crest 3640
		2700 to 5000	crest 3830*
$CaPt(CN)_4$	RR (30)	4770 to 5170	crest 4900
CaI_2	X (28)	4170 to 5000	crest 4570
		5130 to 5880	crest 5520
CuI_2	X (28)	4080 to 4760	crest 4350
HgI_2	X (28)	5400 to 5710	crest 5560
$KLiCl_2$	X (28)	2780 to 3330	crest 3100
		3850 to 5000	crest 4500
$K_2Pt(CN)_4$	X (2)	continuous spectrum	
$KLiPt(CN)_4$	RR (30)	5550 to 5970	crest 5760
$KNaPt(CN)_4$	RR (30)	5340 to 5790	crest 5670
$Li_2Pt(CN)_4$	X (2)	continuous spectrum	
$LiRbPt(CN)_4$	RR (30)	5400 to 5820	crest 5590
$MgPt(CN)_4$	X (2)	continuous spectrum	
$(NH_4)_2Pt(CN)_4$	X (2)	continuous spectrum	
$Rb_2Pt(CN)_4$	RR (30)	4600 to 4850	crest 4760
$Rb_2Pt(CN)_4$	X (2)	continuous spectrum	
$Th[Pt(CN)_4]_2$	X (2)	continuous spectrum	
ZnO	X (28)	4350 to 5130	crest 4830
		5400 to 5880	crest 5630

* Exposure twice as long as for preceding entry.

TABLE 6.—FLAME EXCITATION: TEMPERATURE LIMITS (27)

Certain substances luminesce below 1000°C when placed in that portion of a H-flame which lies between the reducing and the oxidizing zones. The temperature limits (t_1 and t_2) between which luminescence occurs, and the color of the luminescent bands are given below.

Substance	t_1, °C	t_2, °C	Color
Al_2O_3	55	692	Pale green
CaF_2	58	310	Yellow-green
CaO	0	600	Red
CaO	40	725	Green
CaS	60	330	Blue-green
Cb_2O_5	(?)	(?)	*see* Table 5
$Cd_3(PO_4)_2$	50	733	Yellow
MgO	75	680	Blue-green
SiO_2	85	367	White
ZnO	568	704	Red
ZnO	704	948	Green
ZnS	0	123	Yellow
ZnS	211	575	Blue-green
ZrO_2	76	372	Blue-green
ZrO_2	440	720	Red

TABLE 7.—FREQUENCY INTERVALS BETWEEN BANDS

$\Delta_a[\Delta_l]$ = interval in $1/\lambda$ between adjacent members of a set of bands in the absorption [luminescent] spectrum. Frequency intervals are $c\Delta_a$ and $c\Delta_l$. Unit of Δ_a and of Δ_l = 1 $cm.^{-1}$

Uranyl (UO_2) compounds (24); for absorption, *see* (4)

Compound	Δ_l	Δ_a
$Cs_2UO_2Cl_4$	834.4	705.4
$K_2UO_2Cl_4.2H_2O$	835.8	702.2
$(NH_4)_2UO_2Cl_4.2H_2O$	833.2	710.6
$Rb_2UO_2Cl_4.2H_2O$	835.0	708.4
$UO_2SO_4.3H_2O$	852.0	696.0
$Cs_2UO_2(SO_4)_2.2H_2O$	857.0	704
$K_2UO_2(SO_4)_2.2H_2O$	830.0	703.0
$(NH_4)_2UO_2(SO_4)_2.2H_2O$	837.0	703.0
$Na_2UO_2(SO_4)_2.3H_2O$	843.0	713.0
$Rb_2UO_2(SO_4)_2.2H_2O$	832.0	698.0
$UO_2(NO_3)_2.6H_2O$	859.0	714.3
$NH_4UO_2(NO_3)_3$	877.0	743.7
$(NH_4)_2UO_2(NO_3)_4.2H_2O$	842.8	698.7
$KUO_2(NO_3)_3$	869.0	730.7
$K_2UO_2(NO_3)_4$	867.2	734.0
$UO_2(C_2H_3O_2)_2$ (acetate)	859.6	710.4
$UO_2(C_2H_3O_2)_2.2H_2O$	857.2	723.5
$AgUO_2(C_2H_3O_2)_3$	847.4	700.1
$Ba(UO_2)_2(C_2H_3O_2)_6.6H_2O$	850.8	713.6
$Ca(UO_2)_2(C_2H_3O_2)_6.8H_2O$	838.8	705.4
$KUO_2(C_2H_3O_2)_3$	845.7	691.8
$LiUO_2(C_2H_3O_2)_3.3H_2O$	845.0	702.7
$Mg(UO_2)_2(C_2H_3O_2)_6.7H_2O$	851.9	706.0
$MnUO_2(C_2H_3O_2)_4.6H_2O$	851.9	712.5
$NH_4UO_2(C_2H_3O_2)_3$	844.0	701.9
$NaUO_2(C_2H_3O_2)_3$	852.2	704.6
$PbUO_2(C_2H_3O_2)_4.4H_2O$	851.2	712.1
$RbUO_2(C_2H_3O_2)_3$	848.6	707.8
$Sr(UO_2)_2(C_2H_3O_2)_6.6H_2O$	847.4	701.1
$Zn(UO_2)_2(C_2H_3O_2)_6.7H_2O$	845.1	707.7

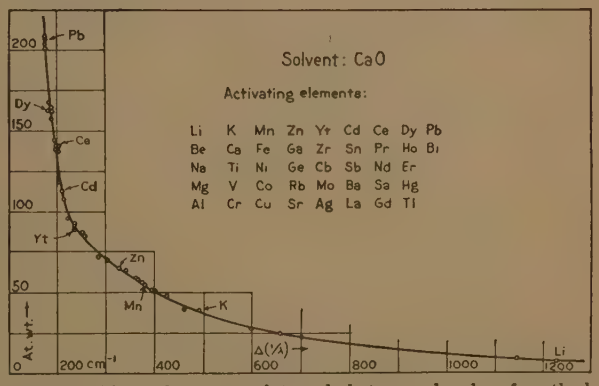

FIG. 2.—Mean frequency interval between bands of cathodoluminescence of solid solutions: Effect of atomic weight of activating element (34).

Elements in solid solution in CaO;* cathodoluminescence (34

	Sets	Δ_l		Sets	Δ_l
Ag	2	212	Bi	1	146
Al	1	598		2	202
Ba	1	199	Ca	2	426
	2	203		2	512
Be	2	1145	Cb	1	215
				2	255

* $CaCO_3$ excited by Fe-spark (25), CaO excited by H-flame (12), and cathodoluminescence of CaO activated with Mn (34), all emit the same two series of bands characterized by Δ_l = 420 cm^{-1}; *see* Fig. 2.

TABLE 7.—(*Continued*)

	Sets	Δ_l		Sets	Δ_l
Cd	1	187	Mo (*Continued*)	2	236
	2	226	Na	2	700
Ce	1	172	Nb	*see* Cb	
	2	223	Nd	1	183
Co	2	322		2	201
	2	399	Ni	2	367
Cr	2	364	Pb	1	165
	2	423		2	185
Cu	2	340	Pr	1	170
Dy	2	182		2	218
Er	2	183	Rb	4	256
Fe	2	374	Sa	1	167
Ga	3	302		2	208
Gd	2	186	Sb	1	191
Ge	2	284		2	212
Gl	*see* Be		Sn	1	199
Hg	1	171		2	206
	2	180	Sr	2	225
Ho	1	186		2	275
K	2	465	Ti	2	424
	2	512	Tl	1	174
La	2	196	V	2	392
Li	1	1218		2	405
	2	1236	Yt	1	223
Mg	1	657		2	243
Mn	2	340	Zn	2	326
	2	420	Zr	1	227
Mo	2	209		2	242

Other substances

Substance	Excited	Series	Δ_l	Lit.
CaO	H-flame	1, 2	420	(12)
$CaCO_3$	Fe-spark	1, 2	420	(25)
Cb_2O_5	H-flame	1, 2	210	(23)

TABLE 8.—VARIATION OF LUMINESCENCE WITH CONCENTRATION

B = brightness; $C = m/M$, $m[M]$ = mass of substance [of solvent*]; ϵ = too weak for measurement. For each mixture the excitation is same for all values of C. Unit of B is arbitrary.

Type	Cathodoluminescence			Fluorescence (38)		
Substance	Sm_2O_3	MnO	MnO*	Fluorescein ($C_{20}H_{12}O_5$)		
Solvent	CaO (6.1)	CaO (6.1)	$Ca_3(PO_4)_2$ (6.2)	H_2O with trace of NH_4OH		
C	B			C	B/C	10^4B†
0	1	0.5	0	5×10^{-9}	21.8	0.001
0.00001	1	2	ϵ	1×10^{-8}	20.6	0.002
0.00010	2	4	ϵ	2×10^{-8}	18.7	0.004
0.00055	4	6		4×10^{-8}	18.8	0.007
0.0010	6	9	8	8×10^{-8}	17.1	0.014
0.0018	8			16×10^{-8}	17.2	0.028
0.0020			16	6×10^{-6}	17.2	1.0
0.0050			21	12×10^{-6}	17.3	2.1
0.0055	10	10		25×10^{-6}	15.7	3.9
0.010	9	9	20	5×10^{-5}	14.3	7.2
0.013	8	8		1×10^{-4}	10.2	10.2
0.03	7			2×10^{-4}	4.39	8.8
0.05			ϵ	4×10^{-4}	1	4.0
0.06		6				
0.1		4	ϵ			
0.3			0			
0.4	4	1	0			
1.0	0	0	0			

*For the solvent $Ca_3(PO_4)_2$, M is mass of the equivalent amount of CaO.
†Computed from B/C, which is corrected for absorption and radiation other than that due to active molecules.

TABLE 9.—MISCELLANEOUS DATA

Fatigue (14).—Esculin ($C_{15}H_{16}O_9$) in H_2O, concentration = 4 in 100 000, continuous excitation by Hg-arc in SiO_2 tube, time (τ) measured from beginning of exposure, brightness (B) in an arbitrary unit.

τ	0	3	6	10	15	21	25	31	41	55	min
B	83	68	57	39	22	12	7	3	2	1	

If $55 \geq \tau \geq 21$ min, $B^{-0.5} = -0.15 + 0.021\tau$.

Decay of Luminescence (35).—N at pressure = 0.22 mm of Hg, excitation by electrodeless discharge for 3.95 sec, time (τ) measured from end of excitation, brightness (B) in an arbitrary unit.

τ	3.70	5.85	8.85	11.30	14.60	19.50	25.65 sec
B	100	50	25	15	10	6	3.5

For this range of τ, $B^{-0.5} = +0.026 + 0.020\tau$.

Energy Emitted during Phosphorescence (10).—ZnS activated by Cu, 1 g Cu to 10^5 g ZnS. Total light = 0.248 candle-second per cm^2; total energy = 6680 erg = 22.5 kg-cal per g-atom of Cu = 0.42 quantum of radiation (λ = 5330 Å) per atom of Cu.

Efficiency of Chemiluminescence (1).—N saturated with vapor of P at 25°C. B = 0.0215 millilambert, efficiency = 1.1 lumen per kilowatt of energy emitted during the reaction.

Effect of Pressure (p) upon Luminescence of N (35).—Excited by continuous electrodeless discharge; brightness (B) in an arbitrary unit.

p	0.080	0.106	0.144	0.192	0.257	0.323	0.440 mm
B	63.3	173	364	902	2 200	4 576	20 400

$B = 129\,000p^3$.

Variation of Fluorescence with Depth.—Owing to absorption, the intensity of the active constituents of the exciting radiation progressively decreases as the radiation penetrates the substance; the brightness (B_x) of the fluorescence excited in the layer at depth x, likewise decreases. The values of B_x for (a) uranium glass, (b) quinine sulfate ($C_{40}H_{50}N_4O_8S$) in H_2O with trace of HNO_3, and (c) fluorescein ($C_{20}H_{12}O_5$) in H_2O with trace of NaOH are as follows (11):

Unit of x = 1 mm; of B_x is arbitrary

x	a	b	c
0	4.60	4.20	1.72
1	3.31	2.88	1.11
2	2.24	2.04	0.54
3	1.70	1.59	0.34
4	1.37	1.10	0.17
5	1.14	0.76	0.12
6	0.95		
7	0.60		
8	0.48		
9	0.36		

Within about ±10 % these can be represented by the expression $B_x = B_0e^{-\mu x}$ where $\mu_a = 0.28$, $\mu_b = 0.34$, $\mu_c = 0.56$. The value of μ will vary with the concentration.

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FLUORESCENCE OF GASES

C. D. Child

There are several distinct types of fluorescence in gases:

1. The simplest type is an atomic phenomenon in which the emitted radiation has the same frequency as the exciting light (**8, 18, 50, 53**). This has been called resonance radiation. The following table shows the wave-lengths (λ) which have been used to excite such radiation in various vapors (unit of λ = 1 Å).

Vapor	λ	Lit.
Bi	2277, 3068	(42, 57)
Cd	2289, 3262	(22, 43)
Hg	1849, 2537	(3, 12, 16, 19, 21, 39, 40, 41, 51, 61, 64, 71)
Li	6708	(1)
Na	3303, 5890, 5896	(56, 60, 66)
Pb	2833	(42, 57)
Tl	2768, 3776	(28, 42, 57)
Zn	2139, 3075	(52, 59)

2. In some cases an atomic vapor will emit certain lines of its arc spectrum of wave-lengths different from those of the exciting light (**14, 42, 57**). Such lines are said to be optically excited.

Many of the mercury lines have been excited in this manner and also λ_{Bi} = 4723; λ_{Pb} = 3640, 4058; λ_{Tl} = 5351, 3530 Å.

3. In a third type, which is a molecular phenomenon, a spectrum of 20 to 40 lines is emitted, one line being of the same frequency as that of the exciting radiation, one to three lines being of higher, and the remainder of lower frequency (**6, 23, 25, 27, 30, 32, 33, 34, 36, 38, 47, 56, 62, 68, 69**). Such spectra are called resonance spectra. In the vapors of I, Na and K they have been excited by a great number of wave-lengths.

4. In a fourth type there is no simple relation between the emitted and the exciting radiation (**7, 9, 26, 31, 35, 37, 42, 46, 54, 57**). In this type the emitted spectrum usually consists of many lines, in some cases it contains bands, and with Hg-vapor at pressure of 0.45 mm Hg it seems to be continuous from the yellow to 3000 Å. This type has been observed with many pure gases, and with the vapors of Hg, I, K and Na when they are mixed with other gases. In some cases the exciting radiation may be changed through wide limits without producing any change in the character of the emitted radiation.

Polarization (**5, 17, 20, 32, 33, 44**).—In the absence of a magnetic field, the radiation in types 1 and 3 is generally polarized in the same direction as the exciting light. The amount of polarization depends upon the gas and upon many external conditions, and in some cases is greatly affected by a weak magnetic field.

The radiation in type 4 has never been found to be polarized.

Effect of Magnetic Fields (**2, 10, 11, 15, 24, 49, 55, 58, 67, 70**).—Magnetic fields are known to affect the polarization and intensity of the radiation in type 1, and the intensity in type 3. The effect on type 1 varies with the direction of emission, and depends on the direction of the field with respect to the direction and plane of polarization of the incident light. In this respect resonance radiation is very sensitive, responding markedly to a field strength of one gauss in the case of Hg2537, and to a field strength of less than 100 gauss for the *D* lines of sodium.

Observations on type 3 have shown that, at least in the case of iodine vapor, the fluorescence is practically extinguished in fields stronger than 30 000 gauss.

General discussion of fluorescence of gases (**4, 45, 63**).

LITERATURE

(For a key to the periodicals see end of volume)

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SPECTRAL SERIES OF THE ELEMENTS[1]

H. M. HANSEN AND V. THORSEN

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INTRODUCTION

Spectral Series.—In most line spectra there have been found certain groups of lines which are distributed in a regular manner. Each of these groups is called a spectral series. In any series the wave number ($1/\lambda$) of every line can be written as a difference between two spectral terms ($1/\lambda = T_1 - T_2$)—combination principle of Rydberg-Ritz (76, 234). Throughout this report λ is the wave-length of the line in a vacuum. For each spectrum, the terms (T), which are much less numerous than the lines, can be arranged in sequences characteristic of the element producing it. On Bohr's theory, $\mathbf{h}\nu(=\mathbf{hc}/\lambda) = E_2 - E_1$, where E_2 and E_1 denote the energy of the emitting atom in two "stationary" states; on this theory, except for an additive constant, $T_1 = -E_1/\mathbf{hc}$, $T_2 = -E_2/\mathbf{hc}$. Hence the spectral terms are often called energy levels of the atom.

If we neglect the "fine structure" of the lines, atoms containing only one electron external to the nucleus (H, He^+, etc.) emit spectra having only one series of terms; $T_H = N_H/m^2$, $T_{He^+} = 4N_{He}/m^2$, where $N_H = 109\ 677.7\ cm^{-1}$, $N_{He} = 109\ 722.1\ cm^{-1}$, $m = 1, 2, 3, \ldots, \infty$. N is called the Rydberg constant, or wave-number, and on Bohr's theory its value for an atom of mass M is $N_M = 2\pi^2\ \mathbf{m}_0\mathbf{e}^4\mathbf{h}^{-3}\mathbf{c}^{-1}\ M/(M + \mathbf{m}_0) = N_\infty M/(M + \mathbf{m}_0)$. The best available values for N_H are 109 677.7 ± 0.2 (16) and 109 677.26 ± 0.23 (246); the former is used by Paschen (228) and others, and is accepted for this report. Taking $M_H/\mathbf{m}_0 = 1847$ (*cf.* Vol. 1, p. 18), this gives $N_M = 109\ 677.7 + 59.37\left(1 - \frac{1}{\text{At. wt.}}\right)$ approx. and $N_\infty = 109\ 737.1$; the latter differs notably from the value derived from the fundamental constants accepted for the I. C. T. (*cf.* Vol. I, p. 17, 18), the difference arising from slight errors in the accepted values for **e**, **h**, and $\mathbf{e}/\mathbf{m}_0$, especially the latter.

If the atom contains more than one external electron, there is more than one sequence of terms. The different sequences are generally designated by the letters $s, p, d, f, \ldots$, and the general terms by ms, mp, . . . (sometimes by (m, s), (m, p), . . .) where m is an integer. In the simplest case the general scheme is as shown in (1)

$$\begin{array}{ccccccccc} 1s & 2s & 3s & 4s & 5s & \ldots & ms & \ldots \\ & 2p & 3p & 4p & 5p & \ldots & mp & \ldots \\ & & 3d & 4d & 5d & \ldots & md & \ldots \\ & & & 4f & 5f & \ldots & mf & \ldots \\ & & & & 5g & \ldots & mg & \ldots \\ & & & & & & mh & \ldots \end{array} \qquad (1)$$

In each sequence the value of the term approaches zero with increasing m and often can approximately be represented by $N_M/(m + \alpha)^2$, where α is a constant. For closer approximations, *see* (76); *cf.* (90). In most spectra the p-terms, d-terms, . . . are multiple, being divisible into 2 or more sequences, denoted as mp_1, mp_2, . . . md_1, md_2, . . . In many spectra 2 or more such systems of multiple-term sequences with different multiplicities occur, the different systems in any spectrum exhibiting either all even or all odd multiplicity. In several spectra there is in addition a distinctly different scheme of terms in which the members of a sequence are approximately represented by the expression $A + \frac{N_M}{(m + \alpha)^2}$. These terms are called anomalous, displaced, or primed terms.

Permissible Lines.—When more than one sequence of terms exists, we do not find lines corresponding to the differences of all possible pairs of terms, but only of certain particular pairs. For the simplest case, scheme 1, lines are rarely found except for the cases indicated in Table 1; these correspond to "permissible" lines.

TABLE 1.—TERM DIFFERENCES CORRESPONDING TO PERMISSIBLE LINES

Series	$1/\lambda$*	m	$1/\lambda$	m	$1/\lambda$	m_1	m_2
Principal	$1s-mp$	>1	$2s-mp$	>2	m_1s-m_2p	>0	$>m_1$
1st subordinate†	$2p-md$	>2	$3p-md$	>3	m_1p-m_2d	>1	$>m_1$
Fundamental‡	$3d-mf$	>3	$4d-mf$	>4	m_1d-m_2f	>2	$>m_1$
	etc.		etc.		etc.		
2nd subordinate§	$2p-ms$	>1	$3p-ms$	>2	m_1p-m_2s	>1	$\leqq m_1$
	$3d-mp$	>2	$4d-mp$	>3	m_1d-m_2p	>2	$\leqq m_1$
	$4f-md$	>3	$5f-md$	>4	m_1f-m_2d	>3	$\leqq m_1$
	etc.		etc.		etc.		

* Generally the strongest of the series. ‡ Bergmann series.
† Diffuse subordinate series. § Sharp subordinate series.

There are similar limitations upon the line-producing differences between the components of multiple terms, as between p_i and d_j, and between terms belonging to different systems of sequences.

The general features of series spectra may be interpreted on Bohr's theory by assuming that in each of the several stationary states involved in the emission of the lines of a series, one electron, the so-called series electron, is moving in an orbit which is large as compared with those of the other electrons, and which differs from state to state, and that this electron has a general central motion; *i.e.*, it has a plane periodic motion on which is superposed a rotation of the orbit in the plane, the plane itself performing a uniform precession around an invariable axis fixed in the atom. For such a motion, the stationary states are characterized by 3 quantum numbers, n, k, j. The main quantum number n is correlated with the period of revolution of the electron, k with the rotation of the orbit in its plane, and j with the precession of the orbital plane. We may write: Angular momentum of electron in plane of orbit $= k\mathbf{h}/2\pi$; total angular momentum of electron $= j\mathbf{h}/2\pi$. For this type of motion, n may change by any integral number at any transition, but the correspondence principle restricts the actual transitions to such as correspond to a change of k by one unit and of j by either one or no unit. This interprets the empirically discovered selection rules of Table 1 if $k = 1$ for the s-sequence, 2 for the p-, 3 for the d-, etc. It also interprets the observed restrictions in the intercombination of the multiple terms if to each component of a multiple term is ascribed a certain value of j. The anomalous or primed terms are interpreted as arising from the simultaneous excitation of more than one electron. It is possible to assign to these terms such quantum numbers k and j that the selection rules governing pairs of primed terms are the same as those for ordinary terms; but those governing combinations involving a primed and an ordinary term, which are characterized by

[1] This section contains data and bibliography to March, 1928, but the report was originally prepared in 1925 and it has been impossible to change the notation and the arrangement of the tables so as to make them accord with the more recent theoretical work (*see* (125)). The numerous, more or less isolated, sets of multiplets which have been discovered are included by literature reference only. All additions to the 1925 report have been made by V. Thorsen, who also took part in the preparation of that report.

special Zeeman patterns, differ, in that k must remain unchanged or must change by two units. On this theory, the capricious appearance of lines corresponding to combinations that do not satisfy these rules is ascribed to the perturbing influence of external forces (20).

The simple model considered in this theory does not offer a sufficient basis for the interpretation of the multiplicity of the terms, the separation of the components of the multiplets, the laws of their anomalous Zeeman effect, and other fine details. Hence it is difficult to assign definite, absolute values to the quantum numbers corresponding to each term. This is especially true of j, for which there is at present no generally accepted assignment; but if the j-value for one sequence is fixed, it is possible in all other sequences of the same spectrum to fix uniquely the j-value in such a way that the only combinations giving permissible lines are those corresponding to the restrictions already mentioned. The values proposed by Sommerfeld (295, 298) for spectra of the simplest types are shown in Fig. 1, where the permissible combinations are shown by connecting lines; in combinations between systems of different multiplicities, that in which j remains unaltered and $= 0$ is not permissible.

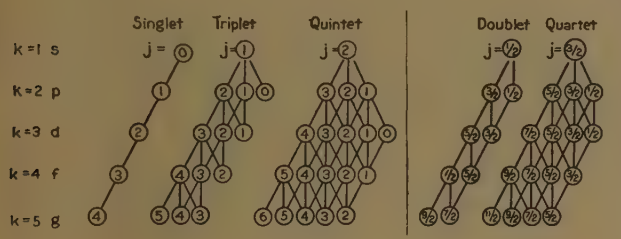

FIG. 1.

Notation Used in This Report.—In view of the uncertainties mentioned, we have refrained from basing the term notation entirely upon the quantum symbols. As the theory is incomplete, we take no account of the theoretical values of n, now used as serial number by Paschen (233), but in general we follow the notation hitherto used by him (234):

1. The serial number of the terms is in accordance with scheme (1) (Ritz-notation), the number 1 being used for the first s-term, 2 for the first p-term, etc. But if the normal state of the atom is not an s-state or if the first s-term is not the largest term in the system, the first s-term is called $2s$. (2) The letter notation of the sequences is in accordance with scheme (1); if there are two systems, capitals are used for sequences of lower multiplicity; in other cases small letters are used. (3) Components of multiple terms are denoted by numerical subscripts, as p_1, p_2, p_3. The subscript 1 is assigned to that term which, from the combination rules and the relative intensities, is inferred to correspond to the highest value of j; this term is the smallest in the ordinary and the largest in the inverse type of system. (4) The so-called anomalous, displaced, or accented terms giving sequences of the type $A + \frac{N_M}{(m+\alpha)^2}$ are denoted by primes, etc. (p', p'', . . .). Primes, . . . are also used for distinguishing the several components of the multiple sets of multiple terms occurring in the systems of Cr, Mo, and Mn. (5) The spectrum of a multiply ionized atom is indicated by placing after the chemical symbol a Roman numeral denoting the multiplicity of the ionization; thus, Si *I*, Si *II*, Si *III*, Si *IV*.

Other Notations.—(1) *Serial Number.*—In his later work, Paschen (233) uses the theoretical value of n as the serial number, but the theory is incomplete. Fowler uses that value of m which makes $\alpha < 1$ or nearly $= 1$ in the expression $N_M/(m+\alpha)^2$; in most spectra this requires our $2p$ term to be called $1p$, our $3d$ term to be called sometimes $2d$ and sometimes $1d$, etc.

2. *Sequence Notation.*—Fowler uses Greek letters $\sigma, \pi, \delta, \varphi, \ldots$ for the doublet system. Our f-terms are denoted by b by Hansen, Takamine, and Werner (115) and some others, and by Δ by Roshdestvenskii (245). Series beyond our f were formerly denoted by $N/5^2$, $N/6^2$, . . . ; Paschen and Fowler now denote them by f', f'', . . . , Roshdestvenskii by Δ^1, Δ^2, . . . , Hansen, Takamine, and Werner (115) by $e, f, g, \ldots$

3. *Components of Multiple Terms.*—Fowler now uses the notation of this report, but formerly, while using that for the p-terms, he used d, d', d'', . . . for the d-terms. Sommerfeld proposes the use of subscripts having the values of j if the multiplicity is odd, and of $(j + \frac{1}{2})$ if multiplicity is even. In the simplest cases the correspondence between the Sommerfeld notation and that here used is as shown below:

Notation	Doublets			Triplets		
Here used	$p_1\ p_2$	$d_1\ d_2$	$f_1\ f_2$	$p_1\ p_2\ p_3$	$d_1\ d_2\ d_3$	$f_1\ f_2\ f_3$
Sommerfeld	$p_2\ p_1$	$d_3\ d_2$	$f_4\ f_3$	$p_2\ p_1\ p_0$	$d_3\ d_2\ d_1$	$f_4\ f_3\ f_2$

4. *Russell and Saunders' Notation* (257).—Russell and Saunders propose that the general term be represented by m^rD_i. For the serial number m they provisionally take the values used by Fowler; capitals replace the small letters in scheme (1), and thus indicate the value of k; r denotes the multiplicity of the term; and i indicates the component of the multiple term; it is intended to be the integral value of j or of $(j + \frac{1}{2})$. The index r may be omitted if term is a singlet, and i may be omitted if it is a singlet or an unresolved multiplet.

TABLE 2.—TERM VALUES FOR SPECTRAL SERIES

Term values are calculated from wave-lengths expressed in the international scale and reduced to vacuum (by tables of Bureau of Standards (199)). Only terms calculated from observed lines are given. Value of n for first term in each sequence is printed in bold face, if known; value of k is indicated by term symbol (for s, $k = 1$; p, $k = 2$; etc.), and of j by lower index of the Russell-Saunders' notation (given in parentheses)—the index $= j$ if the multiplicity is odd, $= j + \frac{1}{2}$ if even. For terms greater than 1000 cm^{-1} the "effective" quantum number (n^*) is given in italics ($n^{*2} = r^2N_M/T$ where T = term value and $(r-1)$ = degree of ionization); errors in n^* may amount to 0.001. For wave-lengths used, *see* (76, 119, 233, 234)† and references mentioned in the table. Graphical representations, *see* (21). ( ) indicates value is uncertain; int. = international; δ = uncertainty in term value; n, k, j = quantum numbers, N = Rydberg constant, based on $N_\infty = 109\,737.1$; series notation, *see* p. 392. Unit of T, δ, and $N = 1\ cm^{-1}$ if 1 int. Å $= 10^{-8}$ cm.

A *Z* = 18. $N_A = 109\,735.6$.

A *I* (204, 205, 206, 272, 273).

A *III* (124).

Ag *Z* = 47. $N_{Ag} = 109\,736.5$.

Ag *I* (129, 239, 243, 283). Limits (76).

m	1	2	3	4	5	6
$ms\ (m^2S_1)$	61 095.9	18 540.0	9 209.0	5 516.2	3 676.6	2 606.5
n; n^*	**5**; *1.330*	*2.433*	*3.451*	*4.461*	*5.539*	*6.489*
$mp_2\ (m^2P_1)$		31 543.6	12 798.7‡			
n; n^*		**5**; *1.865*	*2.981*			
$mp_1\ (m^2P_2)$		30 623.0	12 595.8‡			
n; n^*		**5**; *1.893*	*2.951*			

† In (76) new series formulae have been calculated, λ is expressed in int. Å but N_H is used for all elements; in (233, 234) most λ's are on Rowland's scale; in (233) it is not stated whether term values are based on int. Å or Rowland's scale, and in some instances the scale is not the same for all sequences of the same element.

‡ Calculated from (p, p) combinations; confirmed by observations (283).

Ag *I.*—(*Continued*)

m	1	2	3	4	5	6
md_2 (m^2D_2)			12 351.6	6 891.4	4 394.3	3 040.2
n; *n**			**5**; *2.981*	*3.990*	*4.997*	*6.008*
md_1 (m^2D_3)			12 331.3	6 880.7	4 388.6	3 035.9
n; *n**			**5**; *2.985*	*3.994*	*5.001*	*6.012*
mf (m^2F)				6 891.3	4 386.2	
n; *n**				**4**; *3.990*	*5.002*	

m	7	8	*m*	7	8	9
ms (m^2S_1)	1 957.5	1 526.6	md_1 (m^2D_3)	2 224.6	1 698.3	1 337.3
*n**	*7.488*	*8.478*	*n**	*7.024*	*8.039*	*9.059*

Ag *II* (**9, 184**).

Al $Z = 13$. $N_{Al} = 109\,734.9$.

Al *I* (**130, 202, 222**). Limits (**76**).

m	2	3	4	5	6
ms (m^2S_1)	22 933.3	10 591.6	6 136.8	4 007.7	2 833.2
n; *n**	**4**; *2.187*	*3.219*	*4.228*	*5.233*	*6.223*
mp_2 (m^2P_1)	48 280.9	15 331.7	8 009.2	4 946.0	3 352.6
n; *n**	**3**; *1.508*	*2.675*	*3.702*	*4.710*	*5.722*
mp_1 (m^2P_2)	48 168.8	15 316.5	8 003.2	4 943.2	3 350.6
n; *n**	**3**; *1.509*	*2.677*	*3.703*	*4.711*	*5.724*
md_2 (m^2D_2)		15 845.5	9 351.7	6 047.4	4 114.3
n; *n**		**3**; *2.631*	*3.426*	*4.260*	*5.165*
md_1 (m^2D_3)		15 844.2	9 347.2	6.043.3	4 112.1
n; *n**		**3**; *2.631*	*3.427*	*4.261*	*5.166*
mf (m^2F)			6 962.3	4 451.2	3 087.7
n; *n**			**4**; *3.970*	*4.965*	*5.961*

m	7	8	9	10	11
md_2 (m^2D_2)	2 936.0	2 187.1	1 684.6	1 338.6	1 088.9
*n**	*6.113*	*7.084*	*8.071*	*9.055*	*10.039*
md_1 (m^2D_3)	2 935.1	2 185.7	1 684.3	1 336.9	1 091.0
*n**	*6.114*	*7.086*	*8.071*	*9.060*	*10.029*

Al *II*. Terms: singlet (**278**); *cf.* (**253**), triplet (**232**). Spectrum is analogous to that of Mg *I*.

Singlet system

m	1	2	3	4	5	6
mS (m^1S_0)	151 860.4	56 512.0	35 495.2	19 084.0	13 061.1	9 499.6
n; *n**	**3**; *1.700*	*2.787*	*3.794*	*4.796*	*5.797*	*6.798*
mP (m^1P_1)		92 010.7	44 942.2	25 993.7	16 943.1	11 943.7
n; *n**		**3**; *2.184*	*3.125*	*4.109*	*5.090*	*6.062*
mD (m^1D_2)			66 381.4	41 772.9	27 068.4	17 946.3
n; *n**			**3**; *2.571*	*3.242*	*4.027*	*4.946*
mF (m^1F_3)				28 392.3	18 177.0	12 617.5
n; *n**				**4**; *3.932*	*4.914*	*5.898*

m	7	8	9	10	11	12
mS (m^1S_0)	7 218.5	5 670.3	4 571.6	3 763.3	3 153.5	2 680.6
*n**	*7.798*	*8.798*	*9.779*			
mP (m^1P_1)	8 901.5	6 921.3	5 562.9	4 591.6	3 858.4	3 281.0
*n**	*7.022*	*7.964*	*8.883*	*9.777*		
mD (m^1D_2)	12 573.6	9 253.4	7 080.2	5 586.0	4 517.2	3 727.7
*n**	*5.908*	*6.887*	*7.874*	*8.865*	*9.856*	
mF (m^1F_3)	9 258.8	7 078.5	5 583.9	4 516.2	3 727.8	3 128.8
*n**	*6.885*	*7.875*	*8.886*	*9.859*		

m	13	14	15	16	17	18
mS (m^1S_0)	2 305.7	2 003.8				
mP (m^1P_1)	2 808.5	2 425.6	2 112.4	1 852.8		
mF (m^1F_3)	2 661.2	2 291.8	1 994.2	1 750.7	1 549.3	1 380.7†

† $19^1F_3 = 1\,238.2$; $20^1F_3 = 1\,116.3$.

Triplet system

m	2	3	4	5	6	7
ms (m^3S_1)	60 589.2	31 770.6	19 648.0	13 363.7	9 680.6	7 336.1
n; *n**	**4**; *2.692*	*3.716*	*4.726*	*5.732*	*6.734*	*7.736*
mp_3 (m^3P_0)	114 468.4	46 436.1	26 159.9	16 851.4		
n; *n**	**3**; *1.958*	*3.075*	*4.096*	*5.104*		
mp_2 (m^3P_1)	114 406.6	46 422.0	26 154.2	16 848.3		
n; *n**	**3**; *1.959*	*3.075*	*4.096*	*5.105*		
mp_1 (m^3P_2)	114 281.1	46 392.7	26 141.4	16 841.5	11 767.4	8 680.8
n; *n**	**3**; *1.960*	*3.076*	*4.098*	*5.106*	*6.107*	*7.111*
md_3 (m^3D_1)†		56 311.6	30 379.2			
n; *n**		**3**; *2.792*	*3.801*			
md_2 (m^3D_2)†		56 312.5	30 379.5			
n; *n**		**3**; *2.792*	*3.801*			
md_1 (m^3D_3)†		56 313.6	30 380.1	19 040.7	13 048.5	9 497.6
n; *n**		**3**; *2.792*	*3.801*	*4.802*	*5.800*	*6.798*

Al *II*. Triplet system.—(*Continued*)

m	2	3	4	5	6	7
mf_3 (m^3F_2)			28 444.5‡	18 425.4	13 341.7	10 778.0
n; *n**			**4**; *3.928*	*4.881*	*5.737*	*6.382*
mf_2 (m^3F_3)			28 442.4‡	18 420.0	13 324.0	10 752.9
n; *n**			**4**; *3.928*	*4.881*	*5.740*	*6.389*
mf_1 (m^3F_4)			28 439.6‡	18 413.1	13 301.2	10 719.9
n; *n**			**4**; *3.928*	*4.882*	*5.745*	*6.399*
mf (?)§			28 392.3‡			
n; *n**			**4**; *3.932*			
mg (m^3G)					12 271.7	9 011.2
n; *n**					**6**; *5.981*	*6.979*

m	8	9	10	11	12	13
ms (m^3S_1)	5 751.6	4 631.4	3 807.9	3 188.4		
*n**	*8.783*	*9.734*				
md_1 (m^3D_3)†	7 221.5	5 675.4	4 577.6	3 770.4		
*n**	*7.796*	*8.794*	*9.792*			
mf_3 (m^3F_2)	8 597.7	6 733.9	5 363.7	4 360.6	3 611.7	
*n**	*7.145*	*8.074*	*9.047*	*10.034*		
mf_2 (m^3F_3)	8 590.6	6 731.5	5 362.6	4 360.2	3 611.3	
*n**	*7.148*	*8.075*	*9.048*	*10.034*		
mf_1 (m^3F_4)	8 579.8	6 728.3	5 361.2	4 359.6	3 610.8	3 037.9
*n**	*7.153*	*8.077*	*9.049*	*10.034*		
mg (m^3G)	6 895.7	5 445.9	4 409.4	3 642.8	3 060.0	
*n**	*7.978*	*8.978*	*9.977*			

m	14	15	16	18
mf_1 (m^3F_4)	2 590.9	2 234.9	1 947.2	1 516.9

† *d*-terms are inverse.

‡ 4*f*-terms are double; unusual in triplet systems. $\Delta 4f_3 = 0.254$, $\Delta 4f_2 = 0.490$. $\Delta 4f_1 = 0.100$, $\Delta 4f = 0.489$.

§ Position of this term is not clear. Paschen denoted it by *F*.

Al *III* (**171, 231**). Spectrum analogous to that of Na *I*; *d*-terms are inverse.

m	1	2	3	4	5	6
ms (m^2S_1)	229 454.0	103 291.4	58 816.0	37 952.0		
n; *n**	**3**; *2.074*	*3.092*	*4.098*	*5.103*		
mp_2 (m^2P_1)		175 774.1	85 821.7	51 023.5	33 797.6	
n; *n**		**3**; *2.370*	*3.392*	*4.399*	*5.406*	
mp_1 (m^2P_2)		175 536.1	85 741.6	50 984.4		
n; *n**		**3**; *2.372*	*3.394*	*4.403*		
md_2 (m^2D_2)			113 496.7	63 667.5		
n; *n**			**3**; *2.950*	*3.938*		
md_1 (m^2D_3)			113 499.0	63 668.7	40 578.5	28 079.6
n; *n**			**3**; *2.950*	*3.938*	*4.933*	*5.931*
mf_2 (m^2F_3)				61 841.9	39 578.7	
n; *n**				**4**; *3.996*	*4.995*	
mf_1 (m^2F_4)				61 841.6	39 578.5	27 484.5
n; *n**				**4**; *3.996*	*4.995*	*5.995*
mg (m^2G)					39 526.2	27 452.7
n; *n**					**5**; *4.998*	*5.998*
mh (m^2H)						27 446.7
n; *n**						**6**; *5.998*

m	7	8	*m*	7	8	9
md_1 (m^2D_3)	20 573.6	15 712.6	*mg* (m^2G)	20 171.8	15 443.3	
*n**	*6.929*	*7.928*	*n**	*6.997*	*7.997*	
mf_1 (m^2F_4)	20 193.0	15 461.9	*mh* (m^2H)	20 166.5	15 438.2	12 198.8
*n**	*6.994*	*7.993*	*n**	*6.998*	*7.998*	*8.998*

As $Z = 33$. $N_{As} = 109\,736.3$ (**248**).

Au $Z = 79$. $N_{Au} = 109\,736.8$.

Au *I* (**173, 174, 309**). Hicks (**118**) gives a different arrangement.

m	1	2	3	4	5	6
ms (m^2S_1)	74 407.6	19 922.7	9 665.1	5 728.2	3 790.9	2 662.9
n; *n**	**6**; *1.215*	*2.347*	*3.368*	*4.377*	*5.380*	*6.419*
mp_2 (m^2P_1)		37 048.8				
n; *n**		**6**; *1.721*				
mp_1 (m^2P_2)		33 233.4				
n; *n**		**6**; *1.818*				
md_2 (m^2D_2)			12 455.5	6 938.5	4 437.9	3 053.1†
n; *n**			**6**; *2.969*	*3.977*	*4.973*	*5.995*
md_1 (m^2D_3)			12 373.7	6 895.6	4 398.3	3 015.1†
n; *n**			**6**; *2.978*	*3.989*	*4.996*	*6.033*

† For $m = 7$, $md_2 = 2\,240.5$, $n^* = 6.998$ and $md_1 = 2\,206.1$, $n^* = 7.053$.

B $Z = 5$. $N_B = 109\,731.6$.

B *I* (22, 279); *cf.* (25, 44). Terms (275).

m	2	3	m'	3	4	5
ms (m^2S_1)	27 043	12 075	md (m^2D)	12 315	7 084	4 594
n; n^*	**3**; *2.014*	*3.015*	n; n^*	**3**; *2.985*	*3.936*	*4.886*
mp_2 (m^2P_1)	67 082					
n; n^*	**2**; *1.279*					
mp_1 (m^2P_2)	67 067					
n; n^*	**2**; *1.279*					

B *II* (279). Terms (28).

Singlet system

m	1	2	m	2	m	3
mS (m^1S_0)	194 325.9	66 665.1	mP (m^1P_1)	120 929.4	mD (m^1D_2)	48 410.3
n; n^*	**2**; *1.504*	*2.566*	n; n^*	**2**; *1.905*	n; n^*	**3**; *3.011*

Triplet system

m	2	3	m	3	4	5
ms (m^3S_1)	72 930.8	36 655.5	md (m^3D)	52 054.2	28 640.4	
n; n^*	**3**; *2.453*	*3.461*	n; n^*	**3**; *2.904*	*3.914*	
mp_3 (m^3P_0)			mf (m^3F)			17 795.7
mp_2 (m^3P_1)	165 362.7	59 010.0	n; n^*			**4**; *4.967*
n; n^*	**2**; *1.629*	*2.727*				
mp_1 (m^3P_2)	165 343.9	59 006.5				
n; n^*	**2**; *1.629*	*2.727*				

B *III* (25). $\delta = \pm 5$. Spectrum analogous to that of Li *I*.

m	1	2	m	3	4	5
ms (m^2S_1)	305 938	125 736	md (m^2D)	109 870		
n; n^*	**2**; *1.797*	*2.806*	n; n^*	**3**; *2.998*		
mp_2 (m^2P_1)		257 579	mf (m^2F)		61 742	
n; n^*		**2**; *1.958*	n; n^*		**4**; *3.999*	
mp_1 (m^2P_2)		257 545	mg (m^2G)			39 515
n; n^*		**2**; *1.958*	n; n^*			**5**; *5.000*

Ba $Z = 56$. $N_{Ba} = 109\,736.7$.

Ba *I* (239, 266, 267). Terms: normal (269), anomalous (257).

Singlet system

m	1	2	3	4	5	6
mS (m^1S_0)	42 029.4	16 399.6				
n; n^*	**6**; *1.615*	*2.587*				
mP (m^1P_1)		23 969.2	9 482.2	5 039.5	3 529.9	2 721
n; n^*		**6**; *2.139*	*3.402*	*4.667*	*5.575*	*6.350*
mD (m^1D_2)			30 634.1	13 800.4	7 931.5	4 988.3
n; n^*			**5**; *1.893*	*2.820*	*3.720*	*4.690*
mF (m^1F_3)				13 475.2	6 136.7	4 254.4
n; n^*				**4**; *2.854*	*4.228*	*5.079*

m	7	8	m	7	8
mP (m^1P_1)	2 044	1 606	mD (m^1D_2)	3 473.2	2 532.5
n^*	*7.327*	*8.266*	n^*	*5.620*	*6.583*

Triplet system, normal terms

m	2	3	4	5	6	7
ms (m^3S_1)	15 869.3	8 124.3	4 934.0	3 366.5	2 404.5	
n; n^*	**7**; *2.629*	*3.675*	*4.715*	*5.710*	*6.756*	
mp_3 (m^3P_0)	29 763.3	11 286.4	6 186.9			
n; n^*	**6**; *1.924*	*3.118*	*4.211*			
mp_2 (m^3P_1)	29 392.8	11 214.2	6 137.3			
n; n^*	**6**; *1.935*	*3.128*	*4.228*			
mp_1 (m^3P_2)	28 514.8	11 042.3	6 057.2			
n; n^*	**6**; *1.961*	*3.152*	*4.256*			
md_3 (m^3D_1)		32 995.6	11 333.9	6 320.1	4 067.5	2 888.7
n; n^*		**5**; *1.824*	*3.111*	*4.167*	*5.194*	*6.162*
md_2 (m^3D_2)		32 814.1	11 279.0	6 267.3	4 055.4	2 871.4
n; n^*		**5**; *1.829*	*3.119*	*4.184*	*5.202*	*6.181*
md_1 (m^3D_3)		32 433.0	11 211.6	6 244.2	4 041.0	2 843.8
n; n^*		**5**; *1.840*	*3.128*	*4.192*	*5.210*	*6.212*
mf_3 (m^3F_2)			7 426.8	4 634.6	3 213.8	2 351.2
n; n^*			**4**; *3.845*	*4.866*	*5.844*	*6.832*
mf_2 (m^3F_3)			7 412.8	4 610.4	3 210.1	2 348.7
n; n^*			**4**; *3.847*	*4.879*	*5.847*	*6.835*
mf_1 (m^3F_4)			7 398.6	4 505.3	3 204.2	2 346.3
n; n^*			**4**; *3.851*	*4.935*	*5.852*	*6.839*

Ba *I*. Triplet system, normal terms.—(*Continued*)

m	8	9	10	11	12	13
md_3 (m^3D_1)	2 137.1					
n^*	*7.166*					
md_2 (m^3D_2)	2 134.8	1 649.1				
n^*	*7.170*	*8.157*				
md_1 (m^3D_3)	2 124.2	1 646.8				
n^*	*7.171*	*8.164*				
mf_3 (m^3F_2)	1 790.5	1 415.4	1 134.2	932.2		
n^*	*7.829*	*8.805*	*9.836*			
mf_2 (m^3F_3)	1 788.0	1 407.8	1 132.8	932.9	782.6	665.2
n^*	*7.834*	*8.829*	*9.842*			
mf_1 (m^3F_4)	1 785.2	1 401.6	1 132.2	933.0	781.9	664.7†
n^*	*7.840*	*8.849*	*9.844*			

† $14f_1 = 572.4$, $15f_1 = 499$.

Triplet system, anomalous terms

m	2	3
mp'_3 ($m^3P'_0$)	18 820.3	7 535.6
mp'_2 ($m^3P'_1$)	18 549.3	7 205.9
mp'_1 ($m^3P'_2$)	18 110.5	6 412.8

Ba *II* (165, 244). Term values calculated from data (76) and 4*f*-limit (90); corrected to int. scale. Spectrum analogous to that of Cs *I*.

m	1	2	3	4	5	6
ms (m^2S_1)	80 655.4	38 300.4	22 630.3	14 973	10 704	
n; n^*	**6**; *2.333*	*3.408*	*4.404*	*5.415*	*6.404*	
mp_2 (m^2P_1)		60 393.9				
n; n^*		**6**; *2.696*				
mp_1 (m^2P_2)		58 703.0				
n; n^*		**6**; *2.734*				
md_3 (m^2D_2)			75 781.7†	34 706.0	20 856.3	13 981‡
n; n^*			**5**; *2.407*	*3.557*	*4.588*	*5.603*
md_1 (m^2D_3)			74 980.6†	34 500.7	20 760.8	13 928‡
n; n^*			**5**; *2.419*	*3.567*	*4.598*	*5.613*
mf_2 (m^2F_3)†				32 396.3	21 714	16 184
n; n^*				**4**; *3.681*	*4.495*	*5.209*
mf_1 (m^2F_4)†				32 171.8	21 482	15 960
n; n^*				**4**; *3.694*	*4.521*	*5.244*

† Suggested changes (234, 237) have been made in the values of the 3*d*- and the *f*-terms.

‡ For $m = 7$, $md_2 = 10\,099$, $n^* = 6.593$; $md_1 = 10\,054$, $n^* = 6.607$.

Be $Z = 4$. $N_{Be} = 109\,730.5$.

Be *I* (31); *cf.* (234, 236). Only the triplet system is known.

Symbol	(2^3S_1)	(2^3P_0)	(2^3P_1)	(2^3P_2)	(3^3S_1)	(3^3D)
Term	23 110.2	53 212.9	53 212.2	53 209.8	10 685.0	13 137.5
n; n^*	**3**; *2.179*	**2**; *1.436*	**2**; *1.436*	**2**; *1.436*	*3.204*	**3**; *2.890*

m	4	5	6	7	8
ms (m^2S_1)	6 186.9	4 033.0			
n^*	*4.212*	*5.216*			
md (m^2D)	7 249.2	4 589.7	3 165.7	2 315.5	1 760.1
n^*	*3.890*	*4.889*	*5.888*	*6.886*	*7.896*

Be *II* (31); *cf.* (212). Spectrum is analogous to that of Li *I*.

m	1	2	3	4	5
ms (m^2S_1)	146 880.5	58 649.3	31 424.8	19 546.3	
n; n^*	**2**; *1.729*	*2.735*	*3.738*	*4.739*	
mp_2 (m^2P_1)		114 951.7			
n; n^*		**2**; *1.954*			
mp_1 (m^2P_2)		114 945.1	50 384.7	28 120.2	17 910.2
n; n^*		**2**; *1.954*	*2.951*	*3.951*	*4.950*
md (m^2D)			48 827.4	27 460.4	17 574.6
n; n^*			**3**; *2.998*	*3.998*	*4.997*
mf (m^2F)				27 435.0	17 558.0
n; n^*				**4**; *4.000*	*5.000*

Bi $Z = 83$. $N_{Bi} = 109\,736.8$.

Bi *I* (108, 311, 312); *cf.* (248). System is tentative; inner quantum numbers not assigned.

m	1	2	3	4	5	6
ms		26 157	11 373	6 491	4 194	2 930
n; n^*		**7**; *2.048*	*3.106*	*4.112*	*5.116*	*6.119*
$2p_7$	$2p_6$	$2p_5$	$2p_4$	$2p_3$	$2p_2$	$2p_1$
n^*	n^*	n^*	n^*	n^*	n^*	n^*
58 745	47 327	43 308	37 086	37 084	25 580	17 618
1.355	*1.523*	*1.611*	*1.720*	*1.720*	*2.071*	*2.496*

Bi *I.*—(*Continued*)

m	1	2	3	4	5	6
md_4			14 833	7 727	4 868	
n^*			*2.720*	*3.769*	*4.748*	
md_3			13 928			
n^*			*2.807*			
md_2			13 880	7 588	4 770	
n^*			*2.812*	*3.803*	*4.797*	
md_1			12 830			
n^*			*2.924*			

C $Z = 6$. $N_C = 109\ 731.7$.

C *I* (22, 249).

C *II* (78); *cf.* (22, 87). Limits are not accurately known, and are calculated for $4N_H$ instead of $4N_C$.

m	2	3	4	5	6	7
x† (?)	100 165					
n^*	*2.093*					
ms (m^2S_1)	80 121	39 425	23 311	(15 387)	(10 912)	
n; n^*	**3**; *2.340*	*3.336*	*4.338*	*5.340*	*6.341*	
mp_2 (m^2P_1)	196 670	64 934	34 140			
n; n^*	**2**; *1.494*	*2.599*	*3.585*			
mp_1 (m^2P_2)	196 612	64 923	34 134			
n; n^*	**2**; *1.494*	*2.600*	*3.585*			
md_2 (m^2D_2)		51 108.9	28 535.1			
n; n^*		**3**; *2.930*	*3.921*			
md_1 (m^2D_3)		51 107.6	28 534.7	18 164	(12 558)	(9 193)
n; n^*		**3**; *2.930*	*3.921*	*4.915*	*5.911*	*6.908*
mf (m^2F)			27 680	17 703	12 283	(9 017)
n; n^*			**4**; *3.981*	*4.978*	*5.976*	*6.974*

† This term combines with p_1 and p_2.

C *III* (28).

Singlet system

$1S(1^1S_0)$	375 463.1	**n = 2**; $n^* = 1.622$	$2P(2^1P_1)$	273 111.0	**n = 2**; $n^* = 1.902$

Triplet system

m	2	3	*m*	2	3	4
ms (m^3S_1)	146 197.2		mp_1 (m^3P_2)	331 939.2	124 685.8	
n; n^*	**3**; *2.598*		**n**; n^*	**2**; *1.725*	*2.815*	
mp_2 (m^3P_0)		124 704.1	md (m^3D)		114 387.2	
n; n^*		**2**; *2.815*	**n**; n^*		**3**; *2.939*	
mp_2 (m^3P_1)		124 698.6	mf (m^3F)			62 600.0
n; n^*		**2**; *2.815*	**n**; n^*			**4**; *3.972*

C *IV* (212). $\delta = \pm 100$. Spectrum analogous to that of Li *I*.

m	1	2	*m*	2	3
ms (m^2S_1)	520 034	217 302	mp_1 (m^2P_2)	455 445	
n; n^*	**2**; *1.838*	*2.843*	**n**; n^*	**2**; *1.963*	
mp_2 (m^2P_1)		455 553	md (m^2D)		195 333
n; n^*		**2**; *1.963*	**n**; n^*		**3**; *2.998*

Ca $Z = 20$. $N_{Ca} = 109\ 735.6$.

Ca *I* (128, 154, 222, 257, 265, 267). Terms (76) based on (270). Anomalous terms (41, 104, 237, 257).

Singlet system

m	1	2	3	4	5	6
mS (m^1S_0)	49 304.8	15 988.2	7 518.4	5 028.0	3 417.3	2 469.4
n; n^*	**4**; *1.492*	*2.620*	*3.820*	*4.672*	*5.667*	*6.666*
nP (m^1P_1)		25 652.4	12 573.1	7 625.9	5 371.4	3 879.6
n; n^*		**4**; *2.068*	*2.954*	*3.794*	*4.620*	*5.318*
mD (m^1D_2)			27 455.3	12 006.3	6 385.5	4 314.7
n; n^*			**3**; *2.000*	*3.023*	*4.145*	*5.044*
mF (m^1F_3)				6 961.3	4 500.0	3 122.6
n; n^*				**4**; *3.970*	*4.938*	*5.928*

m	7	8	9	10	11	12
mS (m^1S_0)	1 867.7	1 461.5	1 176.0			
n^*	*7.665*	*8.665*	*9.660*			
mP (m^1P_1)	2 824.6	2 120.3	1 638.2	1 305.9	1 071.6	888.5
n^*	*6.234*	*7.194*	*8.185*	*9.167*	*10.120*	
mD (m^1D_2)	2 994.7					
n^*	*6.053*					
mF (m^1F_3)	2 289.7	1 749.8	1 379.8	1 116.3	919.3	
n^*	*6.923*	*7.919*	*8.918*	*9.915*		

Ca *I*.—(*Continued*)

Triplet system, normal terms

m	2	3	4	5	6
ms (m^3S_1)	17 765.1	8 830.3	5 323.8	3 565.6	2 556.2
n; n^*	**5**; *2.485*	*3.525*	*4.540*	*5.548*	*6.552*
mp_2 (m^3P_0)	34 146.9	12 752.5	6 789.6		
n; n^*	**4**; *1.793*	*2.934*	*4.020*		
mp_2 (m^3P_1)	34 094.6	12 750.3	6 785.6		
n; n^*	**4**; *1.794*	*2.934*	*4.022*		
mp_1 (m^3P_2)	33 988.7	12 730.3	6 777.8	4 342.7	
n; n^*	**4**; *1.797*	*2.936*	*4.023*	*5.027*	
md_2 (m^3D_1)		28 969.1	11 556.4	6 561.4	4 255.5
n; n^*		**3**; *1.946*	*3.082*	*4.090*	*5.078*
md_2 (m^3D_2)		28 955.2	11 552.6	6 559.7	4 254.0
n; n^*		**3**; *1.947*	*3.083*	*4.090*	*5.079*
md_1 (m^3D_3)		28 933.5	11 547.0	6 556.9	4 252.2
n; n^*		**3**; *1.947*	*3.083*	*4.091*	*5.080*
mf (m^3F)			7 133.9†	4 541.5	3 139.5
n; n^*			**4**; *3.922*	*4.915*	*5.912*

m	7	8	9	10	11	12
ms (m^3S_1)	1 922.4	1 498.6	1 201.1	984.1	819.8	
n^*	*7.556*	*8.557*	*9.559*			
md_3 (m^3D_1)	3 002.4	2 268.2	1 848.9	1 551.2	1 272.7	
n^*	*6.046*	*6.958*	*7.704*	*8.411*	*9.286*	
md_2 (m^3D_2)	3 000.6	2 264.5	1 838.7	1 547.0	1 270.7	
n^*	*6.047*	*6.961*	*7.726*	*8.428*	*9.293*	
md_1 (m^3D_3)	2 998.2	2 259.3	1 828.8	1 539.1	1 268.2	1 045.4
n^*	*6.053*	*6.969*	*7.747*	*8.444*	*9.302*	*10.246*
mf (m^3F)	2 298.1	1 754.1	1 382.3	1 117.7	921.3	772.8
n^*	*6.911*	*7.910*	*8.910*	*9.908*		

m	13	14	15	16	17
md_1 (m^3D_3)	869.6	733.8	627.9	541.0	473.5
mf (m^3F)	660				

Triplet system, anomalous terms

m	2	3	4	5	6
mp'_2 ($m^3P'_0$)	10 887.1	780.6	−4 977.5	−8 306.4	
mp'_2 ($m^3P'_1$)	10 839.9	767.1	−4 983.6	−8 313.1	−10 063
mp'_1 ($m^3P'_2$)	10 753.0	741.1	−4 999.8	−8 333.6	−10 086

† 4*f*-term is a triplet.

Ca *II* (74, 75, 165, 244). Term values calculated from data (76) and 4*f*-limit (90); corrected to int. scale. Spectrum analogous to that of K *I*.

m	1	2	3	4	5	6
ms (m^2S_1)	95 723.7	43 556.7	25 046.1	16 294	11 447	
n; n^*	**4**; *2.141*	*3.175*	*4.186*	*5.190*	*6.192*	
mp_2 (m^2P_1)		70 532.1				
n; n^*		**4**; *2.495*				
mp_1 (m^2P_2)		70 309.3				
n; n^*		**4**; *2.499*				
md_2 (m^2D_2)			82 073.5	38 884.5	23 001.6	
n; n^*			**3**; *2.313*	*3.360*	*4.368*	
md_1 (m^2D_3)			82 012.7	38 865.3	22 992.9	15 216†
n; n^*			**3**; *2.314*	*3.360*	*4.369*	*5.371*
mf (m^2F)				27 670	17 707	12 295†
n; n^*				**4**; *3.983*	*4.980*	*5.975*

† For $m = 7$, $md_1 = 10\ 799$, $n^* = 6.375$ and $mf = 9\ 044$, $n^* = 6.967$.

Cb $Z = 41$. $N_{Cb} = 109\ 736.5$ (187).

Cd $Z = 48$. $N_{Cd} = 109\ 736.6$.

Cd *I* (70, 90, 128, 131, 222, 223, 225, 227, 259, 264, 326). Terms (76, 274). Not much difference between value of 2*P*-limits used here and those of Fues (90) when corrected to int. scale.

Singlet system

m	1	2	3	4	5	6
mS (m^1S_0)	72 538.8	19 229.3	9 452.1	5 634.1	3 739.2	2 665.7
n; n^*	**5**; *1.230*	*2.388*	*3.407*	*4.413*	*5.418*	*6.416*
mP (m^1P_1)		28 846.6	12 633	7 038	4 480	3 100
n; n^*		**5**; *1.949*	*2.947*	*3.948*	*4.949*	*5.950*
mD (m^1D_2)			13 319.2	7 404.9	4 701.7	3 246.3
n; n^*			**5**; *2.870*	*3.850*	*4.831*	*5.841*

m	7	*m*	7	8	9
mS (m^1S_0)	1 995.6	mP (m^1P_1)	2 273	1 739	1 371
n^*	*7.418*	n^*	*6.949*	*7.943*	*8.947*

Cd *I*.—(*Continued*)

Triplet system

m	2	3	4	5	6	7
ms (m^3S_1)	21 054.7	9 975.6	5 857.3	3 856.6	2 732.9	2 037.6
n; *n**	**6**; *2.286*	*3.317*	*4.328*	*5.335*	*6.337*	*7.338*
mp_2 (m^3P_0)	42 424.5	14 147.9	7 542.9	4 709.2	3 224.3	
n; *n**	**5**; *1.608*	*2.785*	*3.814*	*4.827*	*5.834*	
mp_2 (m^3P_1)	41 882.6	14 077.2	7 517.5	4 696.7	3 217.4	
n; *n**	**5**; *1.618*	*2.792*	*3.821*	*4.834*	*5.840*	
mp_1 (m^3P_2)	40 711.5	13 903.1	7 446.0	4 663.6	3 198.6	2 331.5
n; *n**	**5**; *1.642*	*2.810*	*3.839*	*4.850*	*5.857*	*6.861*
md_3 (m^3D_1)		13 052.4	7 185.3	4 549.9	3 139.2	
n; *n**		**5**; *2.899*	*3.908*	*4.911*	*5.913*	
md_2 (m^3D_2)		13 040.7	7 179.5	4 546.3	3 138.5	
n; *n**		**5**; *2.901*	*3.909*	*4.913*	*5.913*	
md_1 (m^3D_3)		13 022.5	7 171.3	4 541.3	3 134.3	2 294.5
n; *n**		**5**; *2.903*	*3.912*	*4.915*	*5.917*	*6.916*
mf (m^3F)			6 957.1	(4 445.1)		
n; *n**			**4**; *3.971*	*4.969*		

m	8	9	10	11	12	13
ms (m^3S_1)	1 576.8	1 257.0				
*n**	*3.342*	*3.344*				
md_1 (m^3D_3)	1 751.3	1 379.3	1 114.3	920.3	771.6	658.1†
*n**	*7.916*	*8.919*	*9.924*			

† $14d_1 = 566.7$.

Cd *II* (261). Spectrum analogous to that of Ag *I*.

m	1	2	3	4	5	6
ms (m^2S_1)	136 376.6	53 386.4		18 335.5	12 624.3	9 223.2
n; *n**	**5**; *1.791*	*2.868*		*4.893*	*5.896*	*6.899*
mp_2 (m^2P_1)		92 241.3	41 665.8	24 001.7	15 722.4	
n; *n**		**5**; *2.181*	*3.245*	*4.276*	*5.285*	
mp_1 (m^2P_2)		89 758.1	40 992.5	23 886.3	15 668.0	
n; *n**		**5**; *2.210*	*3.272*	*4.287*	*5.293*	
md_2 (m^2D_2)			46 685.3	26 202.1	16 854.0	11 762.4
n; *n**			**5**; *3.066*	*4.093*	*5.104*	*6.108*
md_1 (m^2D_3)			46 531.0	26 128.6	16 814.2	11 738.9
n; *n**			**5**; *3.071*	*4.099*	*5.109*	*6.114*
mf_2 (m^2F_3)†				27 955.1		12 386.8
n; *n**				**4**; *3.962*		*5.953*
mf_1 (m^2F_4)†				27 942.3	17 828.7	12 403.0
n; *n**				**4**; *3.963*	*4.962*	*5.949*
mg (m^2G)						12 223.2
n; *n**						**6**; *5.993*

m	7	8	9
ms (m^2S_1)	7 033.8	5 540.6	
*n**	*7.900*	*8.901*	
md_2 (m^2D_2)	8 678.8	6 667.6	
*n**	*7.112*	*8.114*	
md_1 (m^2D_3)	8 663.9	6 657.7	5 275.8
*n**	*7.118*	*8.120*	*9.121*
mf_2 (m^2F_3)	9 092.5		
*n**	*6.948*		
mf_1 (m^2F_4)	9 126.5		
*n**	*6.936*		
mg (m^2G)	8 977.9	6 872.1	
*n**	*6.992*	*7.992*	

† Some *f*-pairs are inverse.

Cl $Z = 17$. $N_{Cl} = 109\,735.4$.

Cl *II* (24, 122, 124); **Cl *III* (24, 232)**; **Cl *IV* (24)**; **Cl *V* (24, 213)**; **Cl *VI* (27)**.

Cl *VII* (26).

Co $Z = 27$. $N_{Co} = 109\,736.1$.

Co *I* (56, 57, 200, 316).

Cr $Z = 24$. $N_{Cr} = 109\,736.0$.

Cr *I* (47, 50, 51, 52, 96, 98, 138, 141, 146). Terms **(97)** have been corrected to int. scale; an additional quintet *p*-term is given (7 664.7, 7 575.7, 7 521.1) which is not included here. Here (′) and (″) do not indicate that the term is anomalous. $2P$ terms are inverse.

Cr *I*.—(*Continued*)

Quintet system

m	2	3	4	5	6
mS (m^5S_2)	46 950.0	16 660.0	8 575.1	5 221.4	
n; *n**	**4**; *1.529*	*2.566*	*3.577*	*4.585*	
mP_3 (m^5P_1)	27 741.5	15 632.3	10 066.6	7 477.0	
mP_2 (m^5P_2)	27 747.2				
mP_1 (m^5P_3)	27 755.9				
mP'_3 ($m^5P'_1$)	25 122.1	13 612.8	9 188.5		
mP'_2 ($m^5P'_2$)	24 958.4	13 560.1	9 180.7		
mP'_1 ($m^5P'_3$)	24 718.5	13 499.5	9 165.1		
mP''_3 ($m^5P''_1$)	20 408.1	10 417.0			
mP''_2 ($m^5P''_2$)	20 352.5	10 356.3			
mP''_1 ($m^5P''_3$)	20 291.5	10 283.4			
mD_5 (m^5D_0)		46 792.4			
mD_4 (m^5D_1)		46 732.4	8 972.6		
mD_3 (m^5D_2)		46 615.9	8 954.3		
mD_2 (m^5D_3)		46 448.2	8 922.7		
mD_1 (m^5D_4)		46 235.5	8 877.5		
mF_5 (m^5F_1)			23 755.8	13 636.7	9 440.5
mF_4 (m^5F_2)			23 684.4	13 571.7	9 372.8
mF_3 (m^5F_3)			23 577.8	13 457.0	9 287.6
mF_2 (m^5F_4)			23 436.7	13 318.2	9 156.4
mF_1 (m^5F_5)			23 262.7	13 149.4	8 998.4

Septet system

m	1	2	3	*m*	3	4
ms (m^7S_3)	54 542.8	17 647.5	8 899.5	md_3 (m^7D_1)	12 289.5	6 843.7
n; *n**	**4**; *1.419*	*2.494*	*3.511*	n; *n**	**4**; *2.988*	*4.004*
mp_3 (m^7P_2)		31 238.4		md_4 (m^7D_2)	12 288.3	6 842.4
n; *n**		**4**; *1.874*		n; *n**	**4**; *2.988*	*4.004*
mp_2 (m^7P_3)		31 157.0		md_3 (m^7D_3)	12 286.7	6 840.5
n; *n**		**4**; *1.877*		n; *n**	**4**; *2.989*	*4.005*
mp_1 (m^7P_4)		31 044.5		md_2 (m^7D_4)	12 281.5	6 837.7
n; *n**		**4**; *1.880*		n; *n**	**4**; *2.989*	*4.006*
mp_3 ($m^7P'_2$)		26 814.5		md_1 (m^7D_5)	12 281.7	6 833.2
n; *n**		**4**; *2.023*		n; *n**	**4**; *2.989*	*4.007*
mp_2 ($m^7P'_3$)		26 723.9				
n; *n**		**4**; *2.026*				
mp_1 ($m^7P'_4$)		26 608.1				
n; *n**		**4**; *2.031*				

Cr *II* (138, 194); **Cr *III* (95)**; **Cr *IV* (94)**; **Cr *V* (93)**.

Cs $Z = 55$. $N_{Cs} = 109\,736.7$.

Cs *I* (15, 127, 163, 221, 224, 238, 239, 258, 263) *s*-, *p*-, *d*-terms **(76)**, *f*-, *g*-, *h*-terms **(202, 203)**.

m	1	2	3	4	5	6
ms (m^2S_1)	31 404.6	12 868.9	7 087.8	4 494.9	3 105.5	2 274.0
n; *n**	**6**; *1.869*	*2.920*	*3.934*	*4.941*	*5.944*	*6.947*
mp_2 (m^2P_1)		20 226.3	9 639.2	5 695.3	3 768.4	2 678.2
n; *n**		**6**; *2.392*	*3.374*	*4.390*	*5.396*	*6.401*
mp_1 (m^2P_2)		19 672.3	9 458.1	5 614.7	3 723.3	2 651.4
n; *n**		**6**; *2.362*	*3.406*	*4.421*	*5.429*	*6.433*
md_2 (m^2D_2)			16 905.0	8 815.6	5 356.5	3 592.7
n; *n**			**5**; *2.548*	*3.528*	*4.526*	*5.527*
md_1 (m^2D_3)			16 807.1	8 772.8	5 335.6	3 581.1
n; *n**			**5**; *2.555*	*3.537*	*4.535*	*5.536*
mf_2 (m^2F_3)†				6 934.2	4 435.1	3 076.9
n; *n**				**4**; *3.977*	*4.975*	*5.972*
mf_1 (m^2F_4)†				6 934.4	4 435.3	3 077.0
n; *n**				**4**; *3.977*	*4.975*	*5.972*
mg (m^2G)†					4 895.6	3 059
n; *n**					**5**; *4.997*	*5.990*
mh (m^2H)†						3 049.2
n; *n**						**6**; *5.999*

m	7	8	9	10	11	12
ms (m^2S_1)	1 738					
*n**	*7.946*					
mp_2 (m^2P_1)	2 002.2	1 551.0	1 238.6	1 010.1		
*n**	*7.403*	*8.411*	*9.412*	*10.423*		
mp_1 (m^2P_2)	1 985.1	1 539.6	1 230.6	1 004.8	836.5	707.1
*n**	*7.435*	*8.442*	*9.443*	*10.461*		
md_2 (m^2D_2)	2 575.7	1 936.1	1 508.3	1 208.6	996.4	828.5
*n**	*6.527*	*7.529*	*8.530*	*9.529*		
md_1 (m^2D_3)	2 567.5	1 931.7	1 505.0	1 207.5	988.7	823.1
*n**	*6.537*	*7.537*	*8.539*	*9.533*		

Cs *I.*—(*Continued*)

m	7	8	9	10	11	12
mf_2 (m^2F_3)†	2 258.5	1 727.7	1 364.1	1 104.3	912.1	
*n**	*6.970*	*7.969*	*8.969*	*9.969*		
mf_1 (m^2F_4)†	2 258.5	1 727.8	1 364.2	1 104.3	912.1	765.8
*n**	*6.970*	*7.969*	*8.969*	*9.969*		

m	13	14	15	16	17	18
mp_1 (m^2P_2)	605.4	525.1	459.3	405.8	359.9	322.3

m	19	20	21	22	23	24	25
mp_1 (m^2P_2)	289.1	261.6	238.3	217.5	199.6	183.3	169.4

m	26	27	28	29	30	31	32
mp_1 (m^2P_2)	157.1	145.4	135.9	125.4	117.7	109.6	103.2

† Not quite consistent with terms *s*, *p*, *d*; *f*-terms are inverse.

Cs *II* (5).

Cu $Z = 29$. $N_{Cu} = 109\,736.2$.

Cu *I* (8, 129, 133, 239, 283, 284, 285, 291, 293, 301). Limits (76). Higher terms (307) from observations (116, 323).

m	1	2	3	4	5	6
ms (m^2S_1)	62 308.0	19 171.1	9 459.5	5 636.7	3 739.2	2 659.2
n; *n**	**4**; *1.327*	*2.392*	*3.406*	*4.412*	*5.417*	*6.424*
mp_2 (m^2P_1)		31 772.8	12 957.7†			
n; *n**		**4**; *1.859*	*2.909*			
mp_1 (m^2P_2)		31 524.4	12 925.0†			
n; *n**		**4**; *1.865*	*2.913*			
md_2 (m^2D_2)		49 062.6‡	12 372.8	6 920.8	4 415.2	3 061
n; *n**		(**3**) *1.496*	**4**; *2.978*	*3.982*	*4.986*	*5.988*
md_1 (m^2D_3)		51 105.2‡	12 365.9	6 917.1	4 413.4	3 059.7§
n; *n**		(**3**) *1.466*	**4**; *2.979*	*3.983*	*4.987*	*5.989*
mf (m^2F)				6 879.2	4 401.8	
n; *n**				**4**; *3.994*	*4.993*	

† From combinations with 2*d* found by Werner (320), *see* (21).

‡ $2d_1$ and $2d_2$ are inverse.

§ For $m = 7$, $md_1 = 2\,257.2$, $n^* = 6.974$; for $m = 8$, $md_1 = 1\,721.8$, $n^* = 7.982$.

Cu *II* (286).

F $Z = 9$. $N_F = 109\,734.0$.

F *I* (22, 35, 37, 42, 67, 68, 69).

F *II*, F *III* and F *IV* (22).

Fe $Z = 26$. $N_{Fe} = 109\,736.0$.

Fe *I* (50, 54, 55, 98, 99, 113, 114, 157, 160, 188, 254, 297, 304, 315, 317).

Fe *II* (194).

Ga $Z = 31$. $N_{Ga} = 109\,736.3$.

Ga *I* (235). Limits (314).

m	2	3	4	5	6	7
ms (m^2S_1)	23 593.6	10 797.5	6 224.3	4 050.8	2 852.3	
n; *n**	**5**; *8.156*	*8.187*	*4.199*	*5.204*	*6.202*	
mp_2 (m^2P_1)	48 382.2		8 006.4	4 941.4		
n; *n**	**4**; *1.507*		*3.703*	*4.712*		
mp_1 (m^2P_2)	47 555.9		7 965.3	4 920.5		
n; *n**	**4**; *1.519*		*3.712*	*4.722*		
md_2 (m^2D_2)		13 600.5	7 579.4	4 807.9		
n;† *n**		**4**; *2.841*	*3.805*	*4.778*		
md_1 (m^2D_3)		13 594.2	7 570.9	4 803.4	3 306.8	2 357.1
n;† *n**		**4**; *2.842*	*3.807*	*4.780*	*5.761*	*6.823*

† n changed from value of (21) to accord with observations of (150).

Ga *III* (240).

Ge $Z = 32$.

Ge *I* (91, 176, 242); Ge *IV* (43, 288).

Gl $Z = 4$; *see* Be.

H $Z = 1$. $N_H = 109\,677.7$, $\frac{1}{\lambda} = N_H\left(\frac{1}{m_1^2} + \frac{1}{m_2^2}\right)$, $m_1 < m_2$.

m	1	2	3	4	5	6
N_H/m^2	109 677.7	27 419.4	12 186.41	6 854.85	4 387.11	3 046.60

m	7	8	9	10	11	12
N_H/m^2	2 238.32	1 713.71	1 354.05	1 096.78	906.43	761.65

m	13	14	15	16	17	18
N_H/m^2	648.98	559.58	487.46	428.43	379.51	338.51

H.—(*Continued*)

m	19	20	21	22	23	24
N_H/m^2	303.82	274.19	248.70	226.61	207.33	190.41

m	25	26	27	28	29	30
N_H/m^2	175.48	162.25	150.45	139.90	130.41	121.86†

Series observed: $m_1 = 1$ (167), 2 (6, 327), 3 (221), 4 (33); discussion of data (162); theory of fine structure (18, 19, 294).

† $N_H/(31)^2 = 114.13$.

He $Z = 2$. $N_{He} = 109\,722.2$.

He *I* has 2 systems of terms; He *II* has one.

He *I* (126, 170, 221, 222, 250, 268). Terms (234)

Singlet system ("Parhelium")

m	1	2	3	4	5	6
mS (m^1S)	198 284.1†	32 033.3	13 445.9	7 370.5	4 647.2	3 195.8
n; *n**	**1**; *0.744*	*1.851*	*2.857*	*3.859*	*4.859*	*5.860*
mP (m^1P)		27 175.9	12 101.4	6 818.1	4 368.3	3 035.8
n; *n**		**2**; *2.010*	*3.011*	*4.012*	*5.013*	*6.013*
mD (m^1D)			12 205.8	6 864.3	4 392.5	3 050.0
n; *n**			**3**; *2.998*	*3.998*	*4.998*	*5.998*
mF (m^1F)				6 857.8	4 390.7	
n; *n**				**4**; *4.000*	*5.000*	
mG (m^1G)					4 391	
n; *n**					**5**; *4.999*	

m	7	8	9	10	11	12
mS (m^1S)	2 331.8	1 776.0	1 397.9	1 128.6		780.7‡
*n**	*6.860*	*7.861*	*8.861*	*9.860*		
mP (m^1P)	2 231.6	1 709.4	1 351.1	1 094.6	904.8	760.4
*n**	*7.013*	*8.012*	*9.012*	*10.013*		
mD (m^1D)	2 240.7	1 715.3	1 355.5	1 097.9	907.4	762.5
*n**	*6.998*	*7.998*	*8.999*	*9.998*		

m	13	14	15	16	17	18
mP (m^1P)	648.1	558.9	486.9	428.0	379.1	338.2§
mD (m^1D)	649.8	560.1				

Doublet system ("Orthohelium")

m	2	3	4	5	6	7
ms (m^2S_1)	38 454.7	15 073.9	8 012.5	4 963.7	3 374.5	2 442.4
n; *n**	**2**; *1.689*	*2.698*	*3.701*	*4.702*	*5.703*	*6.703*
mp_2 (m^2P_1)	29 222.9					
n; *n**	**2**; *1.938*					
mp_1 (m^2P_2)	29 223.9	12 746.1	7 093.6	4 509.9	3 117.8	2 283.3
n; *n**	**2**; *1.938*	*2.934*	*3.933*	*4.932*	*5.933*	*6.933*
md (m^2D)		12 209.1	6 866.2	4 393.5	3 050.6	2 241.0
n; *n**		**3**; *2.998*	*3.998*	*4.998*	*5.998*	*6.998*
mf (m^2F)			6 858.2	4 389.0		
n; *n**			**4**; *4.000*	*5.000*		
mg (m^2G)				4 391		
n; *n**				**5**; *4.999*		

m	8	9	10	11	12	13	14
ms (m^2S_1)	1 849.2	1 448.6	1 165.2	958.0	801.3	680.0	583.9
*n**	*7.704*	*8.705*	*9.705*				
mp_1 (m^2P_2)	1 743.9	1 375.3	1 112.4	918.0	770.6	655.9	565.1
*n**	*7.932*	*8.933*	*9.932*				
md (m^2D)	1 715.6	1 355.4	1 097.7	907.2	762.3	649.5	560.1
*n**	*7.998*	*8.998*	*9.998*				

m	15	16	17	18	19	20	21
ms (m^2S_1)	508.4						
mp_1 (m^2P_2)	491.9	432.1	382.5	341.0	305.9	275.9	250.2‖
md (m^2D)	488.0	428.6	379.7	338.3	303.6	273.6	248.5

2*p*-terms are inverse; 5*G* and 5*g* from (233); theoretically doublets should be unresolved triplets, hence Russell-Saunders' notation is doubtful, *cf. j*-values (220, 247); several series which violate the *k* selection rule have been observed in electric fields (71, 147, 164, 300, 313); Lyman (170) records a line which he thinks represents a combination between a doublet and a singlet term.

† (88, 169).

‡ $13S = 655.2$.

§ $19P = 303\,6$, $20P = 274.0$

‖ $22p_1 = 227.9$.

He *II*.

$$\frac{1}{\lambda} = 4N_{He}\left(\frac{1}{m_1^2} - \frac{1}{m_2^2}\right),\ m_1 < m_2$$

m	1	2	3	4	5	6
$4N_{He}/m^2$	438 888.8	109 722.2	48 765.4	27 430.55	17 555.55	12 191.36

m	7	8	9	10	11	12
$4N_{He}/m^2$	8 156.91	6 857.64	5 418.38	4 388.89	3 627.18	3 047.84

m	13	14	15	16	17	18
$4N_{He}/m^2$	2 596.98	2 239.23	1 950.62	1 714.41	1 518.65	1 354.59

m	19	20	21
$4N_{He}/m^2$	1 215.76	1 097.22	995.21

Series observed: $m_1 = 1$ (170), 2 (168), 3 (73), 4 (228); for $m_1 = 4$, lines corresponding to even values of m_2 are observed in stellar spectra and there called Pickering lines of H. Theory of fine structure (18, 19, 294).

Hg $Z = 80$. $N_{Hg} = 109\,736.8$.

Hg *I* (90, 128, 131, 166, 221, 222, 223, 225, 226, 227, 252, 259, 264, 277, 324, 326). Terms: *g*, *h*, *i* (115) very inaccurate, others (234) nearly identical with Fowler's (76). Differentiation of *F*- and *f*-terms not certain. Dingle (66) gives different arrangement.

Singlet system

m	1	2	3	4	5	6
mS (m^1S_0)	84 181.2	20 253.0	9 776.6	5 777.1	3 815.7	
n; n^*	**6**; *1.142*	*2.328*	*3.350*	*4.358*	*5.363*	
mP (m^1P_1)		30 112.5	12 886.1	7 319.0†	5 368.2	4 217.2
n; n^*		**6**; *1.909*	*2.919*	*3.872*	*4.522*	*5.103*
mD (m^1D_2)			12 848.0	7 117.2	4 520.7	3 123.9
n; n^*			**6**; *2.922*	*3.926*	*4.927*	*5.927*
mF (m^1F_3)				6 939.8	4 438.3	
n; n^*				**5**; *3.976*	*4.973*	

m	7	8	9	10	11	12
mP (m^1P_1)	3 026.9	2 237.6	1 717.2	1 355.1	1 097.3	900.8‡
n^*	*6.021*	*7.003*	*7.994*	*9.000*	*10.000*	
mD (m^1D_2)	2 288.1	1 745.8	1 376.1	1 111.5		
n^*	*6.926*	*7.929*	*8.930*	*9.936*		

Triplet system

m	2	3	4	5	6	7
ms (m^3S_1)	21 830.8	10 219.9	5 964.8	3 912.8	2 765.0	2 057.5
n; n^*	**7**; *2.242*	*3.277*	*4.289*	*5.296*	*6.299*	*7.303*
mp_2 (m^3P_0)	46 536.2	14 664.5	7 734.4	4 805.8	3 279.6	2 381.3
n; n^*	**6**; *1.535*	*2.735*	*3.767*	*4.779*	*5.784*	*6.788*
mp_2 (m^3P_1)	44 768.9	14 519.1	7 714.6	4 768.7	3 264.7	2 373.7
n; n^*	**6**; *1.565*	*2.749*	*3.771*	*4.798*	*5.798*	*6.800*
mp_1 (m^3P_2)	40 138.3	12 973.5	7 357.8	4 570§	3 158.4	2 307.4
n; n^*	**6**; *1.653*	*2.908*	*3.862*	*4.900*	*5.893*	*6.896*
md_2 (m^3D_1)		12 845.0	7 096.5	4 502.7	3 110.2	2 279.4
n; n^*		**6**; *2.922*	*3.932*	*4.936*	*5.940*	*6.939*
md_2 (m^3D_2)		12 785.0	7 073.2	4 491.0	3 104.5	2 273.1‖
n; n^*		**6**; *2.930*	*3.938*	*4.943*	*5.945*	*6.948*
md_1 (m^3D_3)		12 749.9	7 051.7	4 478.7	3 096.3	2 269.6
n; n^*		**6**; *2.934*	*3.945*	*4.950*	*5.953*	*6.954*
mf_3 (m^3F_2)			6 938.4	4 436.3		
n; n^*			**5**; *3.976*	*4.974*		
mf_2 (m^3F_3)			6 936.9	4 432.2	3 074.8	2 254.1¶
n; n^*			**5**; *3.977*	*4.977*	*5.974*	*6.977*
mf_1 (m^3F_4)			6 937	4 432		
n; n^*			**5**; *3.977*	*4.977*		
mg (m^3G)				4 395	3 053	2 243
n; n^*				**5**; *4.997*	*5.995*	*6.995*
mh (m^3H)					(3 038)	(2 237)
n; n^*					**6**; *6.010*	*7.004*
mi (m^3I)						(2 216)
n; n^*						**7**; *7.037*

m	8	9	10	11	12	13
ms (m^3S_1)	1 590.3	1 265.6	1 030.7	855.1		616.8
n^*	*8.307*	*9.312*	*10.318*			
mp_2 (m^3P_1)	1 802.3	1 415.4	1 142.0			
n^*	*7.803*	*8.805*	*9.802*			
mp_1 (m^3P_2)	1 759.3	1 387.7	1 120.1	925.2	775.6	662.8
n^*	*7.898*	*8.892*	*9.898*			
md_1 (m^3D_3)	1 734.5	1 366.4	1 105.2	911.7	764.2	650.5
n^*	*7.954*	*8.962*	*9.965*			

Hg *I*. Triplet system.—(*Continued*)

m	14	15	16	17	18	19
ms (m^3S_1)	532.0	464.1	409.4			
mp_1 (m^3P_2)	568.3	493.5	436.0	388.5	347.0	
md_1 (m^3D_3)	559.1	486.8	427.2	376.9	335.4	301.0**

† From (319).
‡ $13P = 761.0$.
§ From (115).
‖ $8d_2 = 1739.4$, $n^* = 7.942$.
¶ $8f_2 = 1723.2$, $n^* = 7.980$.
** $20d_1 = 269.2$, $21d_1 = 243.8$.

In $Z = 49$. $N_{In} = 109\,736.6$.
In *I* (130, 235). Limits (314).

m	2	3	4	5	6	7
ms (m^2S_1)	22 289.2	10 360.4	6 025.2	3 943.4	2 781.2	2 063.0
n; n^*	**6**; *2.219*	*3.254*	*4.268*	*5.276*	*6.281*	*7.294*
mp_2 (m^2P_1)	46 662.1		7 801.2	4 836.7	3 290.7	2 386
n; n^*	**5**; *1.533*		*3.751*	*4.764*	*5.774*	*6.782*
mp_1 (m^2P_2)	44 449.3		7 689.9	4 780.1	3 261.3	2 364
n; n^*	**5**; *1.571*		*3.777*	*4.792*	*5.801*	*6.813*
md_2 (m^2D_2)		13 770.0	7 613.5	4 824.0	3 322.8	2 437
n;† n^*		**5**; *2.823*	*3.796*	*4.770*	*5.747*	*6.710*
md_1 (m^2D_3)		13 746.1	7 564.8	4 800.3	3 304.3	2 439.6
n;† n^*		**5**; *2.825*	*3.808*	*4.782*	*5.763*	*6.707*

m	8	9	10	11	12
ms (m^2S_1)	1 594	1 220			
n^*	*8.298*	*9.484*			
mp_1 (m^2P_2)	1 798				
n^*	*7.812*				
md_1 (m^2D_3)	1 849	1 450	1 168	960	803
n^*	*7.704*	*8.700*	*9.693*		

† n changed from value of (21) to accord with observations of (150).

In *III* (240).
Ir $Z = 77$. $N_{Ir} = 109\,736.8$.
Ir *I* (197).
K $Z = 19$. $N_K = 109\,735.6$.
K *I* (14, 15, 127, 163, 221, 224, 238, 258, 263). *p*-terms (65); others (76) corrected to limit calculated by (65).

m	1	2	3	4	5	6
ms (m^2S_1)	35 008.5	13 982.9	7 558.3	4 735.4	3 243.1	2 360.1
n; n^*	**4**; *1.771*	*2.802*	*3.800*	*4.814*	*5.817*	*6.819*
mp_2 (m^2P_1)		22 023.4	10 307.0	6 011.9	3 938.7	2 780.8
n; n^*		**4**; *2.232*	*3.263*	*4.272*	*5.279*	*6.281*
mp_1 (m^2P_2)		21 965.7	10 288.3	6 003.8	3 934.3	2 778.5
n; n^*		**4**; *2.235*	*3.266*	*4.275*	*5.282*	*6.284*
md (m^2D)			13 472.9†	7 610.9‡	4 824.5	3 312.4
n; n^*			**3**; *2.854*	*3.797*	*4.770*	*5.756*
mf (m^2F)				6 881.1	4 406.8	3 059.1
n; n^*				**4**; *3.994*	*4.991*	*5.990*
mg (m^2G)					4 389.0	
n; n^*					**5**; *4.999*	
mh (m^2H)						3 042.7
n; n^*						**6**; *6.005*

m	7	8	9	10	11	12
ms (m^2S_1)	1 794.1	1 410.3	1 138.8	939.2		
n^*	*7.821*	*8.821*	*9.816*			
mp_2 (m^2P_1)	2 068.4	1 598.4				
n^*	*7.284*	*8.286*				
mp_1 (m^2P_2)	2 066.7	1 597.3	1 271.7	1 036.2	860.8	726.3
n^*	*7.287*	*8.289*	*9.290*	*10.291*		
md (m^2D)	2 410.0	1 830.4	1 436.2	1 158.9	958.5	
n^*	*6.748*	*7.743*	*8.741*	*9.731*		
mf (m^2F)	2 246.9	1 717.4				
n^*	*6.989*	*7.994*				

m	13	14	15	16	17	18
mp_1 (m^2P_2)	621.2	537.1	469.2	413.4	366.9	327.9

m	19	20	21	22	23	24
mp_1 (m^2P_2)	294.8	266.4	242.0	220.8	202.3	186.0

m	25	26	27	28	29	30
mp_1 (m^2P_2)	171.4	158.7	147.2	137.0	127.8	119.6

† $3d$ is double and inverse: $3d_1 - 3d_2 = 2.74$ (64).
‡ Term value uncertain, lines $2p - 4d$ abnormally faint.

K *I.*—(*Continued*)

m	31	32	33	34	35	36
mp_1 (m^2P_2)	112.0	105.1	98.9	93.3	88.2	83.3

m	37	38	39	40	41	42§
mp_1 (m^2P_2)	78.9	74.6	70.6	66.8	63.8	59.8

§ $43p_1 = 57.4$.

K *II* **(34, 36, 62, 63, 219, 249).** **K** *IV* **(124).**

Kr $Z = 36$. $N_{Kr} = 109\,736.4$.

Kr *II* **(135).**

La $Z = 57$. $N_{La} = 109\,736.7$.

La *I* **(106, 107, 190, 191, 192, 237).**

La *II* **(107, 237).**

Li $Z = 3$. $N_{Li} = 109\,728.5$.

Li *I* **(15, 127, 149, 163, 221, 224, 258, 263).** Limits **(76)**.

m	1	2	3	4	5	6
ms (m^2S)	43 486.3	16 280.5	8 475.2	5 187.8	3 500.4	2 535.6
n; n^*	**2**; *1.588*	*2.596*	*3.598*	*4.599*	*5.599*	*6.678*
mp (m^2P)		28 582.5†	12 560.4	7 018.2	4 473.6	3 099.2
n; n^*		**2**; *1.966*	*2.956*	*3.954*	*4.953*	*5.961*
md (m^2D)			12 203.1	6 863.5	4 389.6	3 047.0
n; n^*			**3**; *2.999*	*3.998*	*5.000*	*6.001*
mf (m^2F)				6 856.1	4 381.8	
n; n^*				**4**; *4.000*	*5.005*	
mg (m^2G)					4 386	
n; n^*					**5**; *5.002*	
mh (m^2H)						3 042
n; n^*						**6**; *6.006*

m	7	8	9	10	11	12
mp (m^2P)	2 273.3	1 736.3	1 372.7	1 113.6	917.2	771.7
n^*	*6.948*	*7.749*	*8.941*	*9.927*		
md (m^2D)	2 237.4	1 699.0	1 345.2			
n^*	*7.003*	*8.036*	*9.032*			

m	13	14	15	16	17	18
mp (m^2P)	658.3	560.7	490.7	429.4	381.2	340.3

m	19	20	21	22	23	24
mp (m^2P)	304.9	275.0	248.9	228.3	207.7	188.9

m	25	26	27	28	29	30
mp (m^2P)	175.8	160.8	149.9	142.0	131.1	122.5

m	31	32	33	34	35	36
mp (m^2P)	114.6	107.8	101.4	95.0	90.9	85.8

m	37	38	39	40	41	42
mp (m^2P)	81.6	77.7	73.9	69.4	65.4	62.0

† $2p$ is double, $2p_2 - 2p_1 = 0.34$ **(132, 329)**.

Li *II* **(214, 215, 280, 281, 282, 302, 321, 322).** Terms **(322.5)**. Spectrum analogous to that of He *I*.

Singlet system ("Parlithium")

m	1	2	3	4	5	6
mS (m^1S)	(607 000)	118 718	51 300	28 486	18 083	12 503
n; n^*	**1**; (0.851)	*1.923*	*2.925*	*3.925*	*4.927*	*5.925*
mP (m^1P)		108 263	48 330	27 247		
n; n^*		**2**; *2.013*	*3.014*	*4.014*		
mD (m^1D)			48 804	27 454	17 568	12 200
n; n^*			**3**; *2.999*	*3.998*	*4.998*	*5.998*
mF (m^1F)				27 435	17 557	12 194
n; n^*				**4**; *4.000*	*5.000*	*6.000*

	7^1S	7^1D	7^1F	8^1D	8^1F
Term	9 153	8 962	8 958	6 863	6 857
n^*	*6.925*	*6.998*	*7.000*	*7.997*	*8.001*

Triplet system ("Ortholithium")

m	2	3	4	5	6	7
ms (m^3S)	134 041	55 327	30 097	18 895	12 957	9 438
n; n^*	**2**; *1.810*	*2.817*	*3.819*	*4.820*	*5.820*	*6.820*
mp (m^3P)	115 812	50 578	28 191	17 947	12 422	
n; n^*	**2**; *1.947*	*2.946*	*3.946*	*4.945*	*5.944*	
md (m^3D)		48 834	27 467	17 574	12 203	8 964
n; n^*		**3**; *2.998*	*3.998*	*4.998*	*5.997*	*6.997*
mf (m^3F)			27 435	17 557	12 193	8 958†
n; n^*			**4**; *4.000*	*5.000*	*5.999*	*7.000*

† $8^3F = 6\,858$, $n^* = 8.000$.

Mg $Z = 12$. $N_M = 109\,734.7$.

Mg *I* **(86, 128, 131, 222, 259, 264).** Terms **(76)**; anomalous terms, *see* **(111)**.

Singlet system

m	1	2	3	4	5	6
mS (m^1S_0)	61 672.1	18 169.0	9 115.8	5 485.7	3 661.6	
n; n^*	**3**; *1.334*	*2.467*	*3.470*	*4.473*	*5.474*	
mP (m^1P_1)		26 620.7	12 325.5	6 972.6	4 461	3 103
n; n^*		**3**; *2.030*	*2.984*	*3.966*	*4.960*	*5.947*
mD (m^1D_2)			15 268.9	8 537.4	5 363.6	3 648.7
n; n^*			**3**; *2.681*	*3.686*	*4.624*	*5.484*

m	7	8	9	10	11	12
mP (m^1P_1)	2 277	1 741				
n^*	*6.942*	*7.939*				
mD (m^1D_2)	2 631.6	1 982.7	1 544.9	1 237.0	1 012.3	845.4†
n^*	*6.457*	*7.440*	*8.428*	*9.418*	*10.412*	

Triplet system

m	2	3	4	5	6	7
ms (m^3S_1)	20 474.5	9 799.3	5 781.3	3 817.0	2 709.1	2 022.1
n; n^*	**4**; *2.315*	*3.347*	*4.357*	*5.362*	*6.364*	*7.366*
mp_2 (m^3P_0)	39 821.3					
n; n^*	**3**; *1.660*					
mp_2 (m^3P_1)	39 801.4	13 824.1		4 653.2		
n; n^*	**3**; *1.660*	*2.818*		*4.856*		
mp_1 (m^3P_2)	39 760.5	13 820.0	7 419.0	4 651.9	3 184.5	
n; n^*	**3**; *1.661*	*2.818*	*3.846*	*4.857*	*5.870*	
md (m^3D)		13 714.7	7 479.5	4 704.1	3 229.3	2 352.9
n; n^*		**3**; *2.829*	*3.830*	*4.830*	*5.830*	*6.829*
mf (m^3F)			6 994.8	4 469.0		
n; n^*			**4**; *3.960*	*4.956*		

m	8	9	10	11	12	13
ms (m^3S_1)	1 567.1	1 250.3				
n^*	*8.368*	*9.369*				
md (m^3D)	1 790.3	1 408.5	1 136.4	936.1	784.2	667.6‡
n^*	*7.829*	*8.827*	*9.826*			

† $13D = 716.2$. ‡ $14d = 574.0$.

Mg *II* **(74, 75, 165, 245).** Term values calculated from data **(76)** and $4f$-limit **(90)**, corrected to int. scale. Spectrum analogous to that of Na *I*.

m	1	2	3	4	5	6
ms (m^2S_1)	121 268.8	51 463.6	28 482.6	18 070.7	12 484.1	9 139.0
n; n^*	**3**; *1.903*	*2.920*	*3.925*	*4.928*	*5.930*	*6.931*
mp_2 (m^2P_1)		85 599.4	40 648.0	23 813.9	15 645.7	
n; n^*		**3**; *2.265*	*3.286*	*4.293*	*5.297*	
mp_1 (m^2P_2)		85 507.8	40 617.5	23 799.8	15 638.1	
n; n^*		**3**; *2.266*	*3.287*	*4.294*	*5.299*	
md_2 (m^2D_2)			49 778.4			
n; n^*			**3**; *2.970*			
md_1 (m^2D_3)			49 777.4	27 956.7	17 847.7	12 367.9
n; n^*			**3**; *2.970*	*3.962*	*4.960*	*5.957*
mf (m^2F)				27 468.8	17 578.6	12 206.2
n; n^*				**4**; *3.997*	*4.997*	*5.997*
mg (m^2G)						12 196.0
n; n^*						**6**; *5.999*

m	7	8	9	10	11	12
ms (m^2S_1)	6 976.6	5 502.2				
n^*	*7.932*	*8.932*				
md_1 (m^2D_3)	9 070.8	6 933.1	5 473.1			
n^*	*6.956*	*7.956*	*8.956*			
mf (m^2F)	8 967.0	6 865.2	5 423.7	4 393.1	3 630.5	3 050.4
n^*	*6.996*	*7.996*	*8.996*	*9.996*		
mg (m^2G)	8 958.9	6 860.6	5 420.7	4 390.8	3 628.7	3 049.1
n^*	*6.999*	*7.999*	*8.999*	*9.999*		

Mn $Z = 25$. $N_{Mn} = 109\,736.0$.

Mn *I* **(49, 50, 105, 175).** Terms **(45)** according to theory **(296)**; f-terms **(2)** have been corrected. All d- and f-terms of sextet system are inverse. Here (′), (″), . . . do not indicate that the terms are anomalous.

Sextet system

	mS	mP_3	mP_2	mP_1	mP'_3	mP'_2
m	(m^6S_3)	(m^6P_2)	(m^6P_3)	(m^6P_4)	($m^6P'_2$)	($m^6P'_3$)
1	59 937.5†					
2	18 533.5‡	35 158.2	35 149.5	35 135.2	24 247.4	24 211.7
3	9 032.9§					

† $n^* = 1.353$. ‡ $n^* = 2.432$. § $n^* = 3.486$.

Mn *I*. Sextet system.—(*Continued*)

	mP'_1	mP''_3	mP''_2	mP''_1	mP'''_3	mP'''_2
m	($m^6P'_4$)	($m^6P''_2$)	($m^6P''_3$)	($m^6P''_4$)	($m^6P'''_2$)	($m^6P'''_3$)
2	24 167.5	14 943.6	14 781.4	14 678.3	10 049.5	9 925.1‖

	mD_5	mD_4	mD_3	mD_2	mD_1	mD'_5
m	(m^6D_1)	(m^6D_2)	(m^6D_3)	(m^6D_4)	(m^6D_5)	($m^6D'_1$)
3	42 300.3	42 369.0	42 485.9	42 665.5	42 885.1	17 738.8

	mD'_4	mD'_3	mD'_2	mD'_1	mD''_5	mD''_4
m	($m^6D'_2$)	($m^6D'_3$)	($m^6D'_4$)	($m^6D'_5$)	($m^6D''_1$)	($m^6D''_2$)
3	17 994.0	17 883.8	18 004.8	18 148.0	12 717.7	12 719.4

	mD''_3	mD''_2	mD''_1	mD'''_5	mD'''_4	mD'''_3
m	($m^6D''_3$)	($m^6D''_4$)	($m^6D''_5$)	($m^6D'''_1$)	($m^6D'''_2$)	($m^6D'''_3$)
3	12 722.0	12 725.5	12 730.2	11 619.5	11 636.5	11 666.5¶

	mF_6	mF_5	mF_4	mF_3	mF_2	mF_1
m	(m^6F_1)	(m^6F_2)	(m^6F_3)	(m^6F_4)	(m^6F_5)	(m^6F_6)
4	16 264.5	16 293.0	16 342.0	16 413.3	16 508.9	16 624.2

Octet system

m	2	3	4	5	*m*	3
ms (m^8S_4)	20 506.1	9 779.9	5 757.4	3 793.1	md_5 (m^8D_2)	13 231.3
*n**	*2.314*	*3.346*	*4.365*	*5.379*	*n**	*2.880*
mp_3 (m^8P_3)	41 535.0		7 448.5		md_4 (m^8D_3)	13 230.4
*n**	*1.625*		*3.838*		*n**	*2.880*
mp_2 (m^8P_4)	41 405.8		7 441.1		md_3 (m^8D_4)	13 229.1
*n**	*1.628*		*3.835*		*n**	*2.880*
mp_1 (m^8P_5)	41 232.1	13 956.1	7 431.6	4 675.4	md_2 (m^8D_5)	13 227.3
*n**	*1.631*	*2.804*	*3.843*	*4.844*	*n**	*2.880*

m	3	4	5	6
md_1 (m^8D_6)	13 224.9	7 234.7	4 561.8	3 145.3
*n**	*2.880*	*3.894*	*4.904*	*5.907*
mf (m^8F)		6 962.9	4 438.3	
*n**		*3.969*	*4.978*	

‖ $2P'''_1 = 9\ 838.4$.

¶ $3D'''_2 = 11\ 711.5$; $3D'''_1 = 11\ 769.6$.

Mn *II* (**2, 194**)

Mn *III* (**95**).

Mo $Z = 42$. $N_{Mo} = 109\ 736.5$.

Mo *I* (**48, 52, 193, 325**). Terms and limits (**136**); mP-terms are inverse; here (′) and (″) do not indicate terms are anomalous. (Limits calculated by Catalán (**48, 52**) differ from those used here.)

Quintet system

	2	3	4	*m*	3
mS (m^5S_2)	48 792.2	18 720.1	9 455.3	mD_5 (m^5D_0)	48 594.6
*n**	*1.500*	*2.421*	*3.406*	mD_4 (m^5D_1)	48 417.6
mP_3 (m^5P_1)	30 636.9			mD_3 (m^5D_2)	48 106.1
mP_2 (m^5P_2)	30 723.8			mD_2 (m^5D_3)	47 702.0
mP_1 (m^5P_3)	30 845.3			mD_1 (m^5D_4)	47 214.3

$3D'_5$ ($3^5D'_0$)	$3D'_4$ ($3^5D'_1$)	$3D'_3$ ($3^5D'_2$)	$3D'_2$ ($3^5D'_3$)	$3D'_1$ ($3^5D'_4$)
26 908.2	26 661.8	26 261.4	25 605.5	24 479.4
$3D''_5$ ($3^5D''_0$)	$3D''_4$ ($3^5D''_1$)	$3D''_3$ ($3^5D''_2$)	$3D''_2$ ($3^5D''_3$)	$3D''_1$ ($3^5D''_4$)
22 460.4	22 267.4	21 981.3	21 592.1	21 137.6

Septet system

m	1	2		2	3
ms (m^7S_3)	59 560.4	19 885.0	mp'_1 ($m^7P'_4$)	27 647.0	
*n**; *n**	**5**; *1.557*	*2.349*	md_5 (m^7D_1)		14 624.7
mp_3 (m^7P_2)		33 946.1	md_4 (m^7D_2)		14 620.0
mp_2 (m^7P_3)		33 688.6	md_3 (m^7D_3)		14 613.1
mp_1 (m^7P_4)		33 239.9	md_2 (m^7D_4)		14 603.3
mp'_3 ($m^7P'_2$)		28 260.4	md_1 (m^7D_6)		14 590.5
mp'_2 ($m^7P'_3$)		28 027.0			

Mo *II* (**193, 325**).

N $Z = 7$. $N_N = 109\ 732.9$.

N *I* (**123, 139, 140, 249**).

N *II* (**22, 59, 84, 137, 249**). Fowler (**81**) gives relative values for a singlet and a triplet system.

N *III* (**22**).

Na $Z = 11$. $N_{Na} = 109\ 734.5$.

Na *I* (**15, 64, 127, 148, 163, 221, 224, 258, 263, 328**). Limits (**76**).

m	1	2	3	4	5	6
ms (m^2S_1)	41 449.0	15 709.5	8 248.3	5 077.3	3 437.3	2 480.7
n; *n**	**3**; *1.626*	*2.643*	*3.647*	*4.649*	*5.650*	*6.651*
mp_2 (m^2P_1)		24 492.8	11 181.6	6 408.8	4 152.8	2 908.9
n; *n**		**3**; *2.116*	*3.133*	*4.138*	*5.140*	*6.141*
mp_1 (m^2P_2)		24 475.7	11 176.1	6 406.3	4 151.3	2 907.5
n; *n**		**3**; *2.117*	*3.133*	*4.139*	*5.141*	*6.143*
md (m^2D)			12 276.2	6 900.4	4 412.5	3 061.9
n; *n**			**3**; *2.990*	*3.988*	*4.987*	*5.987*
mf (m^2F)				6 860.4	4 390.4	3 041.5
n; *n**				**4**; *3.999*	*5.000*	*6.006*
mg (m^2G)					4 389.8	
n; *n**					**5**; *5.000*	
mh (m^2H)						3 046.3
n; *n**						**6**; *6.002*

m	7	8	9	10	11	12
ms (m^2S_1)	1 874.5	1 466.0	1 175.5	966.1	804.4	679.5
*n**	*7.651*	*8.652*	*9.662*			
mp_2 (m^2P_1)	2 150.7	1 655.4				
*n**	*7.143*	*8.142*				
mp_1 (m^2P_2)	2 149.8	1 654.1	1 312.3	1 065.9	883.4	743.3
*n**	*7.144*	*8.145*	*9.145*	*10.147*		
md (m^2D)	2 248.6	1 720.9	1 357.2	1 098.7	907.1	761.7
*n**	*6.986*	*7.986*	*8.992*	*9.994*		

m	13	14	15	16	17	18
mp_1 (m^2P_2)	634.9	548.1	478.6	421.1	373.9	333.5
md (m^2D)	647.7	559.0	491			

m	19	20	21	22	23	24
mp_1 (m^2P_2)	299.5	270.3	245.1	223.4	204.7	187.9

m	25	26	27	28	29	30
mp_1 (m^2P_2)	173.3	160.3	148.1	137.9	128.7	120.3

m	31	32	33	34	35	36
mp_1 (m^2P_2)	112.8	106.1	99.9	94.2	89.0	84.2

m	37	38	39	40	41	42
mp_1 (m^2P_2)	79.7	75.5	71.7	68.1	64.9	61.9

m	43	44	45	46	47	48
mp_1 (m^2P_2)	59.0	56.3	53.8	51.5	49.4	47.3

m	49	50	51	52	53	54
mp_1 (m^2P_2)	45.5	43.6	41.9	40.3	38.8	37.4

m	55	56	57	58
mp_1 (m^2P_2)	36.1	35.0	34.4	33.8

Na *II* (**89**).

Nb $Z = 41$; *see* **Cb**.

Ne $Z = 10$. $N_{Ne} = 109\ 734.2$. Ne *I* has 2 systems: "Normal" and "Displaced;" actually, both are equally normal. The term values for normal state (173 918 and 173 918 + 781) correspond to the L_2- and L_3-X-ray levels; ionization potentials = 21.466 and 21.562 volts.

Ne *I*—P = Paschen's original notation, R-S = Russell-Saunders notation. Term values from Paschen (**229, 230**) who states that for some sequences the term value is $A + \frac{N_{Ne}}{n^{*2}}$.

P R-S†	A	Normal terms				
m		2	3	4	5	6
ms_4 mS_1		39 470.2	(15 141.5)‡	8 016.7	4 962.1	3 372.4
n; *n**		**3**; *1.668*	*2.692*	*3.700*	*4.702*	*5.705*
ms_5 mS_2		39 887.6	(15 332.2)‡	8 101.3	5 004.8	3 396.7
n; *n**		**3**; *1.658*	*2.675*	*3.681*	*4.683*	*5.684*
mp_3 mP_2	40.0§	173 918‖	23 012.0	10 528.1	6 062.1	3 952.7
n; *n**		**2**; *0.794*	*2.183*	*3.229*	*4.255*	*5.269*

Ne *I*.—(*Continued*)

P R-S†	A	Normal terms				
m		2	3	4	5	6
$mp_7\ mP_{1a}$			23 807.9	10 916.8	6 289.8	4 089.9
n; n^*			**3**; *2.147*	*3.171*	*4.176*	*5.179*
$mp_{10}\ mP_{1b}$	10§		25 671.7	11 411.5	6 479.9	4 181.3
n; n^*			**3**; *2.067*	*3.101*	*4.115*	*5.123*
$mp_6\ mP_{2a}$			23 613.6	10 891.0	6 280.7	4 085.6
n; n^*			**3**; *2.156*	*3.174*	*4.180*	*5.182*
$mp_8\ mP_{2b}$			24 105.2	11 030.3	6 338.1	4 114.7
n; n^*			**3**; *2.133*	*3.154*	*4.161*	*5.164*
$mp_9\ mP_3$			24 272.4	11 098.7	6 370.3	4 132.3
n; n^*			**3**; *2.126*	*3.144*	*4.151*	*5.153*
$md_6\ mD_0$			12 419.9	6 961.8	4 446.4	3 081.2
n; n^*			**3**; *2.973*	*3.970*	*4.968*	*5.968*
$md_2\ mD_{1a}$			12 292.9	6 902.5	4 412.4	3 061.5
n; n^*			**3**; *2.988*	*3.987*	*4.988*	*5.988*
$md_5\ mD_{1b}$			12 405.2	6 954.1	4 441.0	3 078.1
n; n^*			**3**; *2.974*	*3.972*	*4.971*	*5.971*
$md_1''\ mD_{2a}$			12 229.8	6 881.9	4 403.1	3 056.6
n; n^*			**3**; *2.995*	*3.993*	*4.992*	*5.992*
$md_3\ mD_{2b}$			12 322.3	6 917.9	4 420.9	3 066.5
n; n^*			**3**; *2.984*	*3.983*	*4.983*	*5.983*
$md_1'\ mD_{3a}$			12 228.1	6 880.8	4 402.6	3 056.2
n; n^*			**3**; *2.996*	*3.994*	*4.993*	*5.992*
$md_4\ mD_{3b}$			12 337.3	6 928.4	4 427.1	3 070.5
n; n^*			**3**; *2.988*	*3.979*	*4.979*	*5.979*
$md_4'\ mD_4$			12 339.2	6 929.5	4 427.8	3 071.0
n; n^*			**3**; *2.982*	*3.979*	*4.979*	*5.978*

m	7	8	9	10	11	12	13
$ms_4\ mS_1$	2 440.0	1 848.5	1 447.6	1 164.9	957.1	800.7	
n^*	*6.706*	*7.705*	*8.707*	*9.706*			
$ms_5\ mS_2$	2 456.1	1 858.1	1 454.1	1 169.6	960.9	803.4	
n^*	*6.684*	*7.685*	*8.688*	*9.687*			
$mp_3\ mP_0$	2 780.6		1 602.1				
n^*	*6.281*		*8.277*				
$mp_7\ mP_{1a}$	2 871.4	2 126.2	1 638.0	1 299.2	1 057.5		
n^*	*6.181*	*7.184*	*8.186*	*9.191*	*10.187*		
$mp_{10}\ mP_{1b}$	2 920.1	2 156.5					
n^*	*6.130*	*7.134*					
$mp_6\ mP_{2a}$	2 869.2	2 126.2	1 638.0	1 299.2	1 057.5		
n^*	*6.184*	*7.184*	*8.186*	*9.191*	*10.187*		
$mp_8\ mP_{2b}$	2 885.8	2 137.8	1 642.6				
n^*	*6.166*	*7.165*	*8.173*				
$mp_9\ mP_3$	2 896.5	2 142.4	1 647.2	1 306.2			
n^*	*6.154*	*7.157*	*8.162*	*9.166*			
$md_6\ mD_0$	2 260.3	1 729.1	1 364.5	1 104.9	912.0		
n^*	*6.968*	*7.966*	*8.968*	*9.966*			
$md_2\ mD_{1a}$	2 246.6	1 720.3	1 358.6	1 100.2			
n^*	*6.989*	*7.987*	*8.989*	*9.987*			
$md_5\ mD_{1b}$	2 257.5	1 727.6	1 363.5	1 104.0	911.5	765.8	651.9
n^*	*6.972*	*7.970*	*8.971*	*9.970*			
$md_1''\ mD_{2a}$	2 244.2	1 718.4	1 357.3	1 099.2	908.5	763.3	
n^*	*6.993*	*7.992*	*8.992*	*9.992*			
$md_3\ mD_{2b}$	2 248.1	1 722.7	1 360.1	1 101.5	909.4	764.3	649.3
n^*	*6.987*	*7.982*	*8.983*	*9.981*			
$md_1'\ mD_{3a}$	2 243.9	1 718.2	1 357.2	1 099.2	908.2	762.9	646.5
n^*	*6.993*	*7.992*	*8.992*	*9.992*			
$md_4\ mD_{3b}$	2 253.7	1 724.2	1 361.4	1 102.2	910.6	765.0	651.3
n^*	*6.978*	*7.978*	*8.978*	*9.978*			
$md_4'\ mD_4$	2 254.0	1 724.3	1 361.6	1 102.3	910.6	765.0	651.4
n^*	*6.978*	*7.978*	*8.978*	*9.978*			

P R-S	A	Anomalous terms¶ (Ne *I*)				
m		2	3	4	5	6
$ms_3\ mS_0'$	780.8	39 110.8	(14 651.9)‡	7 323.1	4 223.5	2 616.6
n; n^*		**3**; (*1.658*)	(*2.666*)	(*3.680*)	(*4.683*)	(*5.683*)
$ms_2\ mS_1'$	781.3	38 040.7	(14 506.5)‡	7 273.0	4 201.8	2 605.4
n; n^*		**3**; (*1.681*)	(*2.679*)	(*3.692*)	(*4.693*)	(*5.693*)
$mp_1\ mP_0'$	730.0**	173 918‖	20 958.7	9 643.5	5 342.4	3 240.0
n; n^*		**2**; (*0.793*)	(*2.247*)	(*3.244*)	(*4.233*)	(*5.223*)
$mp_2\ mP_{1a}'$	763.0**		22 891.0	10 221.7	5 570.8	3 351.0
n; n^*			**3**; (*2.153*)	(*3.158*)	(*4.156*)	(*5.155*)
$mp_5\ mP_{1b}'$	783.4		23 157.3	10 272.1	5 573.9	3 344.5
n; n^*			**3**; (*2.141*)	(*3.151*)	(*4.155*)	(*5.157*)
$mp_4\ mP_2'$	780.4		23 070.9	10 220.8	5 550.7	3 332.2
n; n^*			**3**; (*2.145*)	(*3.158*)	(*4.163*)	(*5.165*)
$ms_1'\ mD_1'$	780.6		11 493.8	6 121.7	3 633.4	2 284.6
n; n^*			**3**; (*2.990*)	(*3.987*)	(*4.986*)	(*5.983*)

Ne *I*.—(*Continued*)

P R-S	A	Anomalous terms¶ (Ne *I*)				
m		2	3	4	5	6
$ms_1''\ mD_{2a}'$	780.5		11 509.5	6 132.5	3 640.1	2 287.3
n; n^*			**3**; (*2.988*)	(*3.984*)	(*4.982*)	(*5.981*)
$ms_1''''\ mD_{2b}'$	780.3		11 520.8	6 134.5	3 640.5	2 289.5
n; n^*			**3**; (*2.987*)	(*3.983*)	(*4.982*)	(*5.979*)
$ms_1'''\ mD_3'$	780.4		11 519.3	6 133.6	3 639.8	2 287.0
n; n^*			**3**; (*2.987*)	(*3.984*)	(*4.983*)	(*5.981*)

m	7	8	9	10	11	12
$ms_3\ mS_0'$	1 675.1	1 077.3	674.2	389.5		
n^*	(*6.684*)	(*7.685*)	(*8.684*)	(*9.683*)		
$ms_2\ mS_1'$	1 667.7	1 072.5	670.0	386.2		
n^*	(*6.695*)	(*7.695*)	(*8.697*)	(*9.696*)		
$mp_1\ mP_0'$	2 016.0	1 264.3	747.9	422.9	232.8	115.4
n^*	(*6.263*)	(*7.324*)	(*8.472*)	(*9.447*)	(*10.404*)	
$mp_2\ mP_{1a}'$	2 126.2					
n^*	(*6.143*)					
$mp_5\ mP_{1b}'$	2 107.1	1 355.8	864.0			
n^*	(*6.163*)	(*7.166*)	(*8.168*)			
$mp_4\ mP_2'$	2 101.4	1 356.0				
n^*	(*6.169*)	(*7.166*)				
$ms_1'\ mD_1'$	1 468.4	940.4	578.6	319.9	128.7	
n^*	(*6.985*)	(*7.985*)	(*8.984*)	(*9.984*)		
$ms_1''\ mD_{2a}'$	1 471.0	942.3	580.0	321.0	129.1	
n^*	(*6.981*)	(*7.980*)	(*8.980*)	(*9.979*)		
$ms_1''''\ mD_{2b}'$	1 471.5	942.3	579.9	320.9	129.1	
n^*	(*6.980*)	(*7.980*)	(*8.980*)	(*9.979*)		
$ms_1'''\ mD_3'$	1 470.8	942.2	579.9	320.9	129.1	
n^*	(*6.981*)	(*7.980*)	(*8.980*)	(*9.979*)		

† Lande (151) has given j-values for all terms, and has shown (152) that each system may be regarded as compounded of two; the normal of a triplet and a quintet, and the anomalous of a singlet and a triplet. This resolution can not always be uniquely effected, and this type of resolution is not the only one possible (117), hence the upper index of the R-S notation has been omitted and the 2 terms of same lower index are distinguished (153) by a and b, a denoting the smaller.

‡ Calculated; not based on observed lines.

§ Adding A makes only a little improvement; A not considered in computing n^*.

‖ From (172).

¶ Grotrian (112) claims these correspond to a residue which differs from that for normal terms by 781 cm^{-1} in energy level. Here all terms (normal and anomalous) are reckoned from same zero level, but n^* is calculated from the real term value, which for an anomalous term is (781 + tabulated value); the values of n^* which do not correspond to the tabulated term values are placed in ( ).

** This sequence does not follow the formula closely; A could as well be taken as 781.

Ne *II* (38, 39, 40, 134, 260).
Ni $Z = 28$. $N_{Ni} = 109\,736.1$.
Ni *I* (10, 12, 183, 318). **Ni *II*** (287).
O $Z = 8$, $N_O = 109\,733.4$.
O *I* (221, 251). Terms: $2P$ (17, 121), others (76). 2 P-terms are inverse.

Triplet system

m	1	2	3	4	5	6
mS (m^3S_1)		33 043.3	13 612.5	7 425.6	4 672.8	3 210.2
n; n^*		**3**; *1.823*	*2.840*	*3.843*	*4.846*	*5.847*
mP_3 (m^3P_0)		109 607				
n; n^*		**2**; *1.001*				
mP_2 (m^3P_1)		109 674				
n; n^*		**2**; *1.000*				
mP_1 (m^3P_2)		109 833	21 207.2	10 157.5	5 968.6	
n; n^*		**2**; *1.000*	*2.285*	*3.286*	*4.288*	
mD (m^3D)			12 350.0	6 929.9	4 429.2	3 072.3
n; n^*			**3**; *2.981*	*3.981*	*4.978*	*5.977*

m	7	8	9	10
mS (m^3S_1)	2 340.9	1 780.3	1 401.7	1 130.6
n^*	*6.847*	*7.851*	*8.849*	*9.851*
mD (m^3D)	2 255.4	1 721.4	1 360.3	1 103.7
n^*	*6.976*	*7.984*	*8.982*	*9.971*

O *I.*—(*Continued*)

Quintet system

m	1	2	3	4	5	6
ms (m^5S_2)		36 069.0	14 358.5	7 720.8	4 817.9	3 291.9
n; *n**		**3**; *1.745*	*2.762*	*3.770*	*4.773*	*5.773*
mp$_3$ (m^5P_1)		23 211.9	10 744.3			
n; *n**		**3**; *2.174*	*3.193*			
mp$_2$ (m^5P_2)		23 209.2	10 743.7			
n; *n**		**3**; *2.174*	*3.193*			
mp$_1$ (m^5P_3)		23 205.8	10 742.5			
n; *n**		**3**; *2.175*	*3.192*			
md (m^5D)			12 417.3	6 971.7	4 451.5	3 085.7
n; *n**			**3**; *2.973*	*3.966*	*4.965*	*5.963*

m	7	8	9	10
ms (m^5S_2)	2 391.6	1 815.7	1 425.1	
*n**	*6.774*	*7.774*	*8.775*	
md (m^5D)	2 263.9	1 731.4	1 367.1	1 106.1
*n**	*6.962*	*7.961*	*8.963*	*9.961*

O *II* (**22, 29,60, 61, 82, 85, 207, 255**).

O *III* (**22, 83, 208, 209, 210, 211**).

O *IV* (**22**). **O** *V* (**30**). **O** *VI* (**30**).

Os $Z = 76$. $N_{Os} = 109\,736.8$. **Os** *I* (**197**).

P $Z = 15$. $N_P = 109\,735.2$. **P** *I* (**262**). **P** *II* (**23**).

P *III* (**24, 213**). Spectrum analogous to that of Al *I*.

m	2	3	*m*	3	4
ms (m^2S_1)	125 497.8	67 292.8	*md*$_2$ (m^2D_2)	126 461.4	
n; *n**	**4**; *2.815*	*3.832*	n; *n**	**3**; *2.795*	
mp$_2$ (m^2P_1)	243 332.1	101 957.8	*md*$_1$ (m^2D_3)	126 450.0	70 904.5
n; *n**	**3**; *2.014*	*3.112*	n; *n**	**3**; *2.795*	*3.732*
mp$_1$ (m^2P_2)	242 772.5	101 821.2			
n; *n**	**3**; *2.016*	*3.115*			

P *IV* (**27**). Spectrum analogous to that of Mg *I*. Only triplet system is known.

Triplet system

m	2	3	*m*	3	4
ms (m^3S_1)	187 687.9	105 479.2	*md*$_3$ (m^3D_1)		121 344.0
n; *n**	**4**; *3.058*	*4.081*	*n**		*3.804*
mp$_3$ (m^3P_0)	346 661.4	158 032.4	*md*$_2$ (m^3D_2)		121 338.4
n; *n**	**3**; *2.251*	*3.332*	*n**		*3.804*
mp$_2$ (m^3P_1)	346 432.8	157.973.7	*md*$_1$ (m^3D_3)	225 185.0	121.330.7
n; *n**	**3**; *2.251*	*3.334*	n; *n**	**3**; *2.795*	*3.804*
mp$_1$ (m^3P_2)	345 964.9	157 825.3			
n; *n**	**3**; *2.253*	*3.336*			

P *V* (**26**). Spectrum analogous to that of Na *I*.

m	1	2	3	4	5	6
ms (m^2S_1)	524 491.2	251 540.7	147 858.7			
n; *n**	**3**; *2.287*	*3.303*	*4.307*			
mp$_2$ (m^2P_1)		435 841.8	220 339.0			
n; *n**		**3**; *2.502*	*3.528*			
mp$_1$ (m^2P_2)		435 046.9	220 055.1			
n; *n**		**3**; *2.511*	*3.531*			
md (m^2D)			320 295.0	179 101.1		
n; *n**			**3**; *2.927*	*3.913*		
mf (m^2F)				171 909.4	110 036.5	
n; *n**				**4**; *3.995*	*4.994*	
mg (m^2G)					109 818.4	76 278.5
n; *n**					**5**; *4.998*	*5.997*
mh (m^2H)						76 255.2
n; *n**						**6**; *5.998*

Pb $Z = 82$. $N_{Pb} = 109\,736.8$.

Pb *I* (**3, 101, 102, 182, 299, 305, 305.5, 308, 310**); *p*-and *d*-notations are tentative; small changes in arrangement of *d*-terms have been made, and a new series of *d*-terms suggested; $3d_2$ does not combine with $2p_1$.

j	*m*	2	3	4	5	6	7
1	*ms*	24 524.0	11 124.3	6 300.7	4 091.2	2 872.7	2 123.5†
	n; *n**	**7**; *2.115*	*3.141*	*4.173*	*5.178*	*6.180*	*7.189*
0	*mp*$_4$	59 811.2					
	*n**	*1.364*					
1	*mp*$_3$	51 992.0					
	*n**	*1.463*					

Pb *I*.—(*Continued*)

j	*m*	2	3	4	5	6	7
2	*mp*$_2$	49 160.8					
	*n**	*1.494*					
2	*mp*$_1$	38 353.2					
	*n**	*1.691*					
2	*md*$_4$		14 367.7	7 709.1	4 808.0	3 274.9	2 389.9‡
	*n**		*2.763*	*3.773*	*4.778*	*5.789*	*6.776*
2	*md*$_3$		13 750.2	7 501.1	4 728.8	3 246.7	2 371
	*n**		*2.825*	*3.825*	*4.818*	*5.814*	*6.803*
1	*md*$_2$		13 742.7	7 311.8	4 652.7	3 210.7	2 344§
	*n**		*2.826*	*3.874*	*4.856*	*5.846*	*6.842*
3	*md*$_1$		13 482.3	7 399.3			
	*n**		*2.853*	*3.851*			

† $8s = 1628$, $n^* = 8.210$. ‡ $8d_4 = 1812$, $n^* = 7.782$. § $8d_2 = 1786$, $n^* = 7.839$; $9d_2 = 1400$, $n^* = 8.854$.

Pb *II* (**103**).

Pd $Z = 46$. $N_{Pd} = 109\,736.5$.

Pd *I* (**7, 11, 179, 180, 197**). **Pd** *II* (**180**).

Pt $Z = 78$. $N_{Pt} = 109\,736.8$. **Pt** *I* (**175.5, 197**).

Ra $Z = 88$. $N_{Ra} = 109\,736.8$.

Ra *I*. Spectrum not yet analyzed.

Ra *II* (**90, 244**). Terms (**76**) calculated by (**119**).

m	1	2	3	4
ms (m^2S_1)	82 862.1	39 457.0		
n; *n**	**7**; *2.301*	*3.335*		
mp$_2$ (m^2P_1)		61 510.4		
n; *n**		**7**; *2.671*		
mp$_1$ (m^2P_2)		56 653.2		
n; *n**		**7**; *2.784*		
md$_2$ (m^2D_2)				34 118.1
n; *n**				**7**; *3.587*
md$_1$ (m^2D_3)				33 621.8
n; *n**				**7**; *3.613*

Rb $Z = 37$. $N_{Rb} = 109\,736.4$.

Rb *I* (**15, 127, 163, 221, 224, 238, 239, 258, 263**). Term values (**76**).

m	1	2	3	4	5	6
ms (m^2S_1)	33 689.1	13 557.9	7 378.1	4 642.9	3 191.2	2 328.5
n; *n**	**5**; *1.805*	*2.846*	*3.856*	*4.862*	*5.864*	*6.865*
mp$_2$ (m^2P_1)		21 110.2	9 974.1	5 854.2	3 854.8	2 729.9
n; *n**		**5**; *2.280*	*3.317*	*4.329*	*5.336*	*6.340*
mp$_1$ (m^2P_2)		20 872.6	9 896.6	5 819.2	3 835.5	2 719.6
n; *n**		**5**; *2.293*	*3.331*	*4.342*	*5.349*	*6.351*
md$_2$ (m^2D_2)			14 334.3	7 988.9	5 002.4	3 409.6
n; *n**			**4**; *2.767*	*3.706*	*4.684*	*5.673*
md$_1$ (m^2D_3)				7 985.9	5 000.2	3 407.7
n; *n**				**5**; *3.707*	*4.685*	*5.675*
mf (m^2F)				6 897.6	4 418.2	3 068.0
n; *n**				**4**; *3.989*	*4.984*	*5.981*
mg (m^2G)					4 389.9	
n; *n**					**5**; *5.000*	
mh (m^2H)						3 044.0
n; *n**						**6**; *6.004*

m	7	8	9	10	11	12
ms (m^2S_1)	1 773.8	1 397.4				
*n**	*7.865*	*8.862*				
mp$_2$ (m^2P_1)	2 033.8					
*n**	*7.345*					
mp$_1$ (m^2P_2)	2 028.2	1 573.3	1 254.8	1 024.2	849.3	718.0
*n**	*7.356*	*8.351*	*9.363*	*10.351*		
md$_2$ (m^2D_2)	2 468.2	1 868.8	1 464.6	(1 182.7)		
*n**	*6.668*	*7.663*	*8.656*	*9.633*		
md$_1$ (m^2D_3)	2 467.0	1 867.6	1 463.5	1 176.7		
*n**	*6.669*	*7.665*	*8.660*	*9.657*		
mf (m^2F)	2 252.4					
*n**	*6.980*					

m	13	14	15	16	17	18
mp$_1$ (m^2P_2)	614.6	531.7	464.1	409.7	363.6	325.3

m	19	20	21	22	23	24
mp$_1$ (m^2P_2)	292.0	265.2	240.8	219.2	201.7	186.0

m	25	26	27	28	29	30
mp$_1$ (m^2P_2)	170.6	157.5	146.3	136.2	127.1	119.1†

† $31p_1 = 111.1$.

Rh $Z = 45$. $N_{Rh} = 109\ 736.5$.
Rh *I* (197, 292, 293).
Ru $Z = 44$. $N_{Ru} = 109\ 736.5$.
Ru *I* (195, 196, 197, 289, 290).
S $Z = 16$. $N_S = 109\ 735.2$.
S *I* (124, 251). Terms: triplet (17) from measurements (120); others (76), 1*s* is from measurements of (201).

Triplet system

m	$mS\ (m^3S_1)$ n; *n**	$mP_3\ (m^3P_0)$ n; *n**	$mP_2\ (m^3P_1)$ n; *n**	$mP_1\ (m^3P_2)$ n; *n**	$mD\ (m^3D)$ n; *n**
2	28 229	82 982	83 156	83 554	
	4; *1.972*	**3**; *1.150*	**3**; *1.149*	**3**; *1.146*	
3	12 204				15 665
	2.999				**3**; *2.648*
4	6 835	(9 288)	(9 290)	(9 291)	
	4.006	*3.437*	*3.437*	*3.437*	

Quintet system

m	2	3
$ms\ (m^5S_2)$	30 936.9	
n; *n**	**4**; *1.883*	
$mp_3\ (m^5P_1)$	20 114.7	9 649.5
n; *n**	**4**; *2.336*	*3.372*
$mp_2\ (m^5P_2)$	20 103.4	9 645.9
n; *n**	**4**; *2.337*	*3.373*
$mp_1\ (m^5P_3)$	20 085.5	9 639.9
n; *n**	**4**; *2.338*	*3.374*

m	$ms\ (m^5S_2)$ *n**	$md\ (m^5D)$ n; *n**
5	4 502.5	5 290.2
	4.936	**5**; *4.554*
6	3 111.6	3 568.3
	5.939	*5.646*
7	2 278.9	2 565.7
	6.940	*6.639*
8	1 741.1	1 931.8†
	7.939	*7.636*

† For $m = 9$, $md = 1\ 506.8$, $n^* = 8.533$; for $m = 10$, $md = 1\ 207.8$, $n^* = 9.533$.

S *II*, **S** *III*. Spectrum not yet analyzed.
S *IV*. (24, 213). Spectrum analogous to that of Al *I*.

m	2	3	*m*	3	4
$ms\ (m^2S_1)$	200 109.2	110 531.0	$md_2\ (m^2D_2)$	229 414.3	
n; *n**	**4**; *2.963*	*3.985*	n; *n**	**3**; *2.766*	
$mp_2\ (m^2P_1)$	381 541.4	168 034.0	$md_1\ (m^2D_3)$	229 400.0	126 151.6
n; *n**	**3**; *2.145*	*3.233*	n; *n**	**3**; *2.766*	*3.731*
$mp_1\ (m^2P_2)$	380 591.2	167 824.0			
n; *n**	**3**; *2.148*	*3.234*			

S *V* (27). Spectrum analogous to that of Mg *I*. Only triplet system is known.

Triplet system

m	2	3	*m*	2	3
$ms\ (m^3S_1)$	273 075.0		$mp_1\ (m^3P_2)$	500 497.7	235 191.6
n; *n**	**4**; *3.170*		n; *n**	**3**; *2.341*	*3.415*
$mp_3\ (m^3P_0)$	501 618.2	235 568.6	$md\ (m^3D)$		349 700.0
n; *n**	**3**; *2.339*	*3.413*	n; *n**		**3**; *2.801*
$mp_2\ (m^3P_1)$	501 252.4	235 480.7			
n; *n**	**3**; *2.340*	*3.413*			

S *VI* (26). Spectrum analogous that of Na *I*.

m	1	2	3	4	5
$ms\ (m^2S_1)$	710 264.2	347 264.0			
n; *n**	**3**; *2.358*	*3.373*			
$mp_2\ (m^2P_1)$		604 398.2	309 083.5		
n; *n**		**3**; *2.557*	*3.575*		
$mp_1\ (m^2P_2)$		603 131.1	308 625.9		
n; *n**		**3**; *2.558*	*3.577*		
$md_2\ (m^2D_2)$			462 854.4		
n; *n**			**3**; *2.921*		
$md_1\ (m^2D_3)$			462 818.2		
n; *n**			**3**; *2.921*		
$mf\ (m^2F)$				247 612.1	
n; *n**				**4**; *3.994*	
$mg\ (m^2G)$					158 159.5
n; *n**					**5**; *4.998*

Sb $Z = 51$. $N_{Sb} = 109\ 736.6$ (248).
Sc $Z = 21$. $N_{Sc} = 109\ 735.8$.
Sc *I* (46, 50, 50.5, 58, 94, 100, 109, 186, 256)
Sc *II* (50.5, 186, 194, 237, 256).
Sc *III* (92).
Se $Z = 34$. $N_{Se} = 109\ 736.3$.

Se *I* (177, 251). Terms (76). Only the quintet system is known.

m	1	2	3	4	5	6
$ms\ (m^5S_2)$					4 449.1	3 085.0
n; *n**					**3**; *4.967*	*5.964*
$mp_3\ (m^5P_1)$		19 416.2				
n; *n**		**5**; *2.377*				
$mp_2\ (m^5P_2)$		19 371.4				
n; *n**		**5**; *2.380*				
$mp_1\ (m^5P_3)$		19 267.7				
n; *n**		**5**; *2.386*				
$md\ (m^5D)$					5 112.5	3 462.1
n; *n**					**5**; *4.633*	*5.629*

m	7	8	9	10	11
$ms\ (m^5S_2)$	2 261.5	1 729.3			
*n**	*6.966*	*7.965*			
$md\ (m^5D)$	2 498.2	1 887.9	1 472.2	1 184.3	973.2
*n**	*6.628*	*7.624*	*8.634*	*9.627*	

Si $Z = 14$. $N_{Si} = 109\ 735.0$.
Si *I* (80). **Si** *II* (24, 79, 80). **Si** *III* (79, 80).
Si *IV* (80). Terms (77) corrected (26) to basis of N_{Si}.

m	1	2	3	4	5	6
$ms\ (m^2S_1)$	364 109	170 138	98 699			
n; *n**	**3**; *2.196*	*3.212*	*4.218*			
$mp_2\ (m^2P_1)$		292 822	145 850	87 613		
n; *n**		**3**; *2.449*	*3.470*	*4.477*		
$mp_1\ (m^2P_2)$		292 362	145 688	87 538		41 719†
n; *n**		**3**; *2.451*	*3.472*	*4.479*		*6.487*
$md\ (m^2D)$			203 738	114 109	72 627	
n; *n**	$m = 7$	$m = 8$	**3**; *2.936*	*3.922*	*4.916*	
$mf\ (m^2F)$	35 925	27 491†		109 987	70 399	48 895
n; *n**	*6.991*	*7.992*		**4**; *3.995*	*4.994*	*5.993*
$mg\ (m^2G)$	35 868				70 277	48 813
n; *n**	*6.996*				**5**; *4.999*	*5.997*
$mh\ (m^2H)$						48 797
n; *n**						**6**; *5.998*

† From (178).

Sn $Z = 50$. $N_{Sn} = 109\ 736.6$.
Sn *I* (4, 110, 181, 299, 306). *j*-values (299).

j	*m*	2	3	4	5	6	7
1	*ms*	24 245	10 936	6 135	4 021	2 856	2 129
	n; *n**	**6**; *2.127*	*3.168*	*4.229*	*5.223*	*6.198*	*7.180*
0	mp_3	59 158					
	*n**	*1.362*					
1	mp_2	57 466					
	*n**	*1.382*					
2	mp_1	55 731					
	*n**	*1.404*					
?	mX_3	55 443					
	*n**	*1.407*					
2	mX_2	50 546					
	*n**	*1.473*					
0	mX_1	41 997					
	*n**	*1.616*					
†	md_2		15 015	8 147	5 146	3 466	2 499
	*n**		*2.704*	*3.670*	*4.618*	*5.626*	*6.627*
‡	md_2		14 650	7 995		3 414	
	*n**		*2.737*	*3.705*		*5.670*	
§	md_1		14 583	7 405		3 351	
	*n**		*2.743*	*3.850*		*5.723*	

j	*m*	8	9	10	11
1	*ms*	1 633	1 303	1 059	873
	*n**	*8.197*	*9.178*	*10.180*	

† $j_3 = 2$, $j_4 = j_6 = 1$. ‡ $j_3 = j_6 = 1$, $j_4 = 2$. § $j_3 = j_4 = 3$, $j_6 = 1$.

Sn *II* (216, 217). Terms (110). Spectrum analogous to that of In *I*.

m	2	3	4	5
$ms\ (m^2S_1)$	60 821	33 000	20 293	
n; *n**	**6**; *2.686*	*3.646*	*4.650*	
$mp_2\ (m^2P_1)$	117 704	46 213	24 980	
n; *n**	**5**; *1.931*	*3.081*	*4.191*	
$mp_1\ (m^2P_2)$	113 451	45 329	24 623	
n; *n**	**5**; *1.966*	*3.111*	*4.221*	
$md_2\ (m^2D_2)$		46 301	27 467	
n; *n**		**5**; *3.078*	*3.977*	

Sn *II*.—(*Continued*)

m	2	3	4	5
md_1 (m^2D_2)		45 658	27 360	17 857
n; *n**		**5**; *3.100*	*4.005*	*4.956*
mf (m^2F)			28 416	18 056
n; *n**			**4**; *3.930*	*4.930*

Sn *III* (241). Terms (110). Spectrum analogous to that of Cd *I*.

Singlet system

m	1	2	3	*m*	4	5
mS (m^1S_0)	243 235			mF (m^1F_3)	61 475	39 611
n; *n**	**5**; *2.015*			n; *n**	**4**; *4.006*	*4.994*
mP (m^1P_1)		163 327	80 517	mG (m^1G_4)		39 133
n; *n**		**5**; *2.459*	*3.502*	n; *n**		**5**; *5.024*
mD (m^1D_2)			99 650			
n; *n**			**5**; *3.148*			

Triplet system

m	2	3	*m*	3	4	5
ms (m^3S_1)	103 604		md_1 (m^3D_3)	101 404		
n; *n**	**6**; *3.088*		n; *n**	**5**; *3.121*		
mp_2 (m^3P_0)	189 691	83 302	mf_3 (m^3F_3)		63 937	
n; *n**	**5**; *2.282*	*3.443*	n; *n**		**4**; *3.930*	
mp_2 (m^3P_1)	188 044	83 026	mf_2 (m^3F_3)		63 900	
n; *n**	**5**; *2.291*	*3.449*	n; *n**		**4**; *3.931*	
mp_1 (m^3P_2)	184 011	81 802	mf_1 (m^3F_4)		63 802	
n; *n**	**5**; *2.317*	*3.475*	n; *n**		**4**; *3.934*	
md_3 (m^3D_1)		101 921	mg (m^3G)			39 158
n; *n**		**5**; *3.113*	n; *n**			**5**; *5.000*
md_2 (m^3D_2)		101 716				
n; *n**		**5**; *3.116*				

Sr $Z = 38$. $N_{Sr} = 109\ 736.4$.

Sr *I* (72, 128, 239, 259, 267). Terms: normal (271); anomalous (257).

Singlet system

m	1	2	3	4	5	6
mS (m^1S_0)	45 925.6	15 334.5	7 481.6	4 873.1	3 329.6	2 412.8
n; *n**	**5**; *1.545*	*2.675*	*3.830*	*4.745*	*5.741*	*6.744*
mP (m^1P_1)		24 227.1	11 827.5	7 019.0	4 753.5	3 463.4
n; *n**		**5**; *2.128*	*3.045*	*3.953*	*4.805*	*5.628*
mD (m^1D_2)			25 776.3	11 110.0	6 192.4	4 093.7
n; *n**			**4**; *2.063*	*3.143*	*4.209*	*5.177*
mF (m^1F_3)				6 387.0	4 406.9	3 086.8
n; *n**				(**4**) *4.145*	*4.991*	*5.962*

m	7	8	9	10	11	12
mS (m^1S_0)	1 828.3					
*n**	*7.747*					
mP (m^1P_1)	2 598.8	1 989.2	1 559.8	1 251.0	1 022.0	
*n**	*6.498*	*7.428*	*8.388*	*9.366*	*10.362*	
mD (m^1D_2)	2 904.7	2 145.0				
*n**	*6.146*	*7.153*				
mF (m^1F_3)	2 269.9	1 735.8	1 370.0	1 106.9	913.9	765.6†
*n**	*6.953*	*7.951*	*8.950*	*9.957*		

† $13F = 648.1$.

Triplet system, normal terms

m	2	3	4	5	6	7
ms (m^3S_1)	16 886.8	8 500.9	5 163.2	3 473.7	2 498.0	1 882.0
n; *n**	**6**; *2.549*	*3.591*	*4.610*	*5.620*	*6.629*	*7.636*
mp_2 (m^3P_0)	31 608.0	12 109.8	6 525.0			
n; *n**	**5**; *1.863*	*3.010*	*4.101*			
mp_2 (m^3P_1)	31 421.1	12 068.4	6 510.2			
n; *n**	**5**; *1.869*	*3.015*	*4.106*			
mp_1 (m^3P_2)	31 026.8	11 963.6	6 479.1			
n; *n**	**5**; *1.880*	*3.024*	*4.115*			
md_3 (m^3D_1)		27 766.0	10 918.3	6 239.4	4 061.1	2 858.7
n; *n**		**4**; *1.988*	*3.170*	*4.193*	*5.197*	*6.195*
md_2 (m^3D_2)		27 706.4	10 903.3	6 234.5	4 056.5	2 855.1
n; *n**		**4**; *1.991*	*3.172*	*4.195*	*5.200*	*6.199*
md_1 (m^3D_3)		27 606.0	10 880.5	6 222.2	4 051.0	2 850.6
n; *n**		**4**; *1.994*	*3.176*	*4.200*	*5.204*	*6.204*
mf_3 (m^3F_3)			7 174.6	4 560.4	3 160.5	2 314.5
n; *n**			**4**; *3.911*	*4.905*	*5.892*	*6.886*
mf_2 (m^3F_3)			7 172.9	4 559.6	3 159.9	2 312.6
n; *n**			**4**; *3.911*	*4.905*	*5.892*	*6.888*
mf_1 (m^3F_4)			7 170.2	4 558.7	3 147.6	2 301.1
n; *n**			**4**; *3.912*	*4.906*	*5.904*	*6.906*

Sr *I*. Triplet system, normal terms.—(*Continued*)

m	8	9	10	11	12	13
ms (m^3S_1)	1 467.7					
*n**	*8.647*					
md_3 (m^3D_1)	2 123.7	1 641.7				
*n**	*7.189*	*8.176*				
md_2 (m^3D_2)	2 120.5	1 638.4	1 307.0	1 065.4		
*n**	*7.194*	*8.184*	*9.163*	*10.149*		
md_1 (m^3D_3)	2 116.4	1 634.0	1 300.3	1 060.5	881.5	‡
*n**	*7.201*	*8.195*	*9.187*	*10.173*		
mf_1 (m^3F_4)	1 753.5	1 380.5	1 115.3	919.7	769.6	651.2
*n**	*7.911*	*8.915*	*9.920*			

Triplet system, anomalous terms

m	2	3
mp'_3 ($m^3P'_0$)	10 731.8	1 399.8
mp'_2 ($m^3P'_1$)	10 525.5	1 329.6
mp'_1 ($m^3P'_2$)	10 250.7	1 195.9

‡ $14d_1 = 638.0$, $15d_1 = 552.8$.

Sr *II* (74, 75, 165, 244). Term values calculated from data (76) and 4*f*-limit (90); corrected to int. scale. Spectrum analogous to that of Rb *I*.

m	1	2	3	4	5	6
ms (m^2S_1)	88 854.7	41 118.2	23 891.1	15 614.8		
n; *n**	**5**; *2.222*	*3.267*	*4.286*	*5.302*		
mp_2 (m^2P_1)		65 139.5				
n; *n**		**5**; *2.595*				
mp_1 (m^2P_2)		64 338.0				
n; *n**		**5**; *2.611*				
md_2 (m^2D_2)			74 297.9	35 568.4	21 332.2	14 233.0
n; *n**			**4**; *2.431*	*3.513*	*4.536*	*5.552*
md_1 (m^2D_3)			74 017.8	35 482.8	21 292.1	14 211.7†
n; *n**			**4**; *2.435*	*3.517*	*4.541*	*5.558*
mf (m^2F)				27 862.6	17 798	12 314†
n; *n**				**4**; *3.962*	*4.966*	*5.970*

† For $m = 7$, $md_1 = 10\ 195$, $n^* = 6.561$; $mf = 8998$, $n^* = 6.985$.

Te $Z = 52$. $N_{Te} = 109\ 736.6$.

Te *I* (177).

Ti $Z = 22$. $N_{Ti} = 109\ 735.9$.

Ti *I* (50, 100, 142, 144).

Ti *II* (94, 194, 303).

Ti *IV* (92).

Tl $Z = 81$. $N_{Tl} = 109\ 736.8$.

Tl *I* (130, 222). Limits (76).

m	2	3	4	5	6	7
ms (m^2S_1)	22 786.7	10 518.3	6 098.2	3 968.2	2 808.9	2 085.0
n; *n**	**7**; *2.195*	*3.230*	*4.242*	*5.259*	*6.250*	*7.254*
mp_2 (m^2P_1)	49 264.2	15 104.6	7 895.9	4 883.3	3 324.9	2 410.4†
n; *n**	**6**; *1.493*	*2.696*	*3.728*	*4.740*	*5.746*	*6.747*
mp_1 (m^2P_2)	41 471.5	14 103.4	7 523.2	4 701.7	3 220.6	2 347.1
n; *n**	**6**; *1.627*	*2.790*	*3.819*	*4.831*	*5.837*	*6.837*
md_2 (m^2D_2)		13 146.2	7 252.8	4 591.6	3 165.8	2 314.1
n;‡ *n**		**6**; *2.889*	*3.889*	*4.888*	*5.887*	*6.886*
md_1 (m^2D_3)		13 064.3	7 215.2	4 571.5	3 153.9	2 306.4
n;‡ *n**		**6**; *2.898*	*3.900*	*4.899*	*5.898*	*6.898*
mf (m^2F)			6 945.8	4 440.7		2 244.9
n; *n**			**5**; *3.975*	*4.972*		*6.992*

m	8	9	10	11	12	13
ms (m^2S_1)	1 610.2	1 282.3	1 040.0	865.3	730.5	626.0§
*n**	*8.256*	*9.251*	*10.272*			
mp_1 (m^2P_2)	1 786.2	1 416	1 135	933	805	
*n**	*7.839*	*8.803*	*9.833*			
md_1 (m^2D_3)	1 760.1	1 385.9	1 120.3	923.5	774.6	659.0‖
*n**	*7.896*	*8.898*	*9.897*			

† $8p_2 = 1\ 821.6$, $n^* = 7.762$.

‡ n from (150).

§ $14s = 536.5$.

‖ $14d_1 = 565.7$, $15d_1 = 491.9$.

V $Z = 23$. $N_V = 109\ 735.9$

V *I* (13, 50, 53, 100, 155, 156, 185).

V *II* (189, 194).

V *III* (94).

V *IV* (93).

W $Z = 74$. $N_W = 109\,736.8$.
W *I* (158, 159).
Yt $Z = 39$. $N_{Yt} = 109\,736.4$.
Yt *I* (186, 193, 198).
Yt *II* (193, 237).
Yt *III* (32).

m	2	3	m	3	4
ms (m^2S_1)	157 822.9	78 572.6	md_2 (m^2D_2)	165 289.2	76 910.4
n; n^*	**5**; *2.502*	*3.546*	n; n^*	**4**; *2.444*	*3.584*
mp_2 (m^2P_1)	123 888.7		md_1 (m^2D_3)	164 565.8	76 711.4
n; n^*	**5**; *2.823*		n; n^*	**4**; *2.460*	*3.588*
mp_1 (m^2P_2)	122 335.0		mf (m^2F)		64 200.0
n; n^*	**5**; *2.842*		n; n^*		**4**; *3.916*

Zn $Z = 30$. $N_{Zn} = 109\,736.2$.
Zn *I* (90, 128, 131, 222, 223, 225, 227, 259, 264, 276, 277, 326). Terms (76, 274). Not much difference between value of 2*P*-limits used here and those of Fues (90) when corrected to int. scale.

Singlet system

m	1	2	3	4	5	6
mS (m^1S_0)	75 766.8	19 978.7	9 729.5	5 763.7	3 812.5	2 709.4
n; n^*	**4**; *1.204*	*2.343*	*3.358*	*4.363*	*5.365*	*6.364*
mP (m^1P_1)		29 021.7	12 857.9	7 160.6	4 559.1	3 141.7†
n; n^*		**4**; *1.944*	*2.921*	*3.914*	*4.906*	*5.910*
mD (m^1D_2)			13 308.6	7 428.9	4 719.2	(3 276)
n; n^*			**4**; *2.871*	*3.843*	*4.822*	*5.788*

Triplet system

m	2	3	4	5	6	7
ms (m^3S_1)	22 094.4	10 334.4	6 019.7	3 943.2	2 780.5	2 068.2
n; n^*	**5**; *2.228*	*3.259*	*4.269*	*5.276*	*6.281*	*7.285*
mp_3 (m^3P_0)	43 455.0	14 519.4	7 695.8	4 789.2	3 270.2	2 375.9
n; n^*	**4**; *1.589*	*2.749*	*3.776*	*4.787*	*5.793*	*6.796*
mp_2 (m^3P_1)	43 265.0	14 492.7	7 686.0	4 784.5	3 267.6	2 374.0
n; n^*	**4**; *1.592*	*2.752*	*3.779*	*4.790*	*5.795*	*6.799*
mp_1 (m^3P_2)	42 876.3	14 436.5	7 664.9	4 774.2	3 262.0	2 370.3
n; n^*	**4**; *1.599*	*2.757*	*3.783*	*4.795*	*5.800*	*6.805*
md_3 (m^3D_1)		12 997.6	7 187.0			
n; n^*		**4**; *2.905*	*3.908*			
md_2 (m^3D_2)		12 994.2	7 185.9			
n; n^*		**4**; *2.906*	*3.908*			
md_1 (m^3D_3)		12 988.7	7 183.9	4 553.1	3 139.9	2 295.6
n; n^*		**4**; *2.906*	*3.908*	*4.909*	*5.912*	*6.914*
mf (m^3F)			6 931.3	(4 442.3)		
n; n^*			**4**; *3.979*	*4.971*		

m	8	9	10	11	12	13
ms (m^3S_1)	1 597.5	1 270.8				
n^*	*8.288*	*9.293*				
md_1 (m^3D_3)	1 751.0	1 380.1	1 114.4	917.0	772.6	654.4
n^*	*7.917*	*8.917*	*9.923*			

† For $m = 7$, $mP = 2\,298.2$, $n^* = 6.911$; for $m = 8$, $mP = 1\,755.5$, $n^* = 7.907$.

Zn *II* (261). Spectrum analogous to that of Cu *I*.

m	1	2	3	4	5	6
ms (m^2S_1)	144 890.2	56 454.4	30 393.9	19 011.6	13 014.2	9 468.1
n; n^*	**4**; *1.741*	*2.788*	*3.800*	*4.805*	*5.808*	*6.809*
mp_2 (m^2P_1)		96 410.1	43 525.4	25 002.4		
n; n^*		**4**; *2.134*	*3.176*	*4.190*		
mp_1 (m^2P_2)		95 536.5	43 280.3	24 931.6	16 219.0	
n; n^*		**4**; *2.143*	*3.185*	*4.196*	*5.202*	
md_2 (m^2D_2)			79 450.0†	47 982.2	26 922.4	17 261.3
n; n^*			**4**; *2.350*	*3.025*	*4.038*	*5.043*
md_1 (m^2D_3)			82 169.0†	47 931.4	26 898.2	17 248.3
n; n^*			**4**; *2.311*	*3.026*	*4.040*	*5.045*
mf_2 (m^2F_3)					17 681.1	12 287.3
n; n^*					**5**; *4.983*	*5.977*
mf_1 (m^2F_4)				27 628.0	17 691.7	12 252.1
n; n^*				**4**; *3.986*	*4.981*	*5.985*
mg (m^2G)						12 207.3
n; n^*						**6**; *5.996*

† Values of n^* show these do not belong to *md*-series. These and some of the -pairs are inverse.

Zn *II*.—(*Continued*)

m	7	8	9	m	7	8
md_2 (m^2D_2)	12 010.2	8 839.0	(6 777.0)	mf_1 (m^2F_4)	9 002.0	6 885.1
n^*	*6.045*	*7.047*	*8.048*	n^*	*6.983*	*7.985*
md_1 (m^2D_3)	12 003.0	8 834.5	6 773.8	mg (m^2G)	8 968.1	
n^*	*6.047*	*7.049*	*8.050*	n^*	*6.996*	
mf_2 (m^2F_3)	8 999.2					
n^*	*6.984*					

Zn *III* (161).
Zr $Z = 40$. $N_{Zr} = 109\,736.4$.
Zr *I* (143).
Zr *II* and Zr *III* (145).
Zr *IV* (32).

m	2	m	3	4
ms (m^2S_1)	238 545.9	md_2 (m^2D_2)	276 803.5	
n; n^*	**5**; *2.713*	n; n^*	**4**; *2.527*	
mp_2 (m^2P_1)	194 827.4	md_1 (m^2D_3)	275 553.3	
n; n^*	**5**; *3.002*	n; n^*	**4**; *2.523*	
mp_1 (m^2P_2)	192 344.4	mf (m^2F)		117 725.0
n; n^*	**5**; *3.021*	n; n^*		**4**; *3.862*

LITERATURE

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(10) Bechert, *8*, **77**: 537; 25. (11) Bechert and Catalán, *96*, **35**: 449; 26. (12) Bechert and Sommer, *8*, **77**: 351; 25. (13) Bechert and Sommer, *96*, **31**: 145; 25. (14) Bergmann, *99*, **6**: 113; 08. (15) Bevan, *5*, **83**: 421; 10. **85**: 54; 11. **86**: 320; 12. (16) Birge, *2*, **17**: 589; 21. (17) Birge, *48*, **8**: 233; 24. (18) Bohr, *3*, **29**: 332; 15. (19) Bohr, *214*, **4**: No. 1, I: 18.
(20) Bohr, *214*, **4**: No. 1, III: 22. (21) Bohr, *8*, **71**: 228; 23. (22) Bowen, *2*, **29**: 231; 27. (23) Bowen, *2*, **29**: 510; 27. (24) Bowen, *2*, **31**: 34; 28. (25) Bowen and Millikan, *197*, **10**: 199; 24. (26) Bowen and Millikan, *2*, **25**: 295; 25. (27) Bowen and Millikan, *2*, **25**: 591; 25. (28) Bowen and Millikan, *2*, **26**: 310; 25. (29) Bowen and Millikan, *58*, **118**: 410; 26.
(30) Bowen and Millikan, *2*, **27**: 144; 26. (31) Bowen and Millikan, *2*, **28**: 256; 26. (32) Bowen and Millikan, *2*, **28**: 923; 26. (33) Brackett, *21*, **56**: 154; 22. (34) de Bruin, *96*, **38**: 94; 26. (35) de Bruin, *96*, **39**: 869; 26. (36) de Bruin, *64P*, **29**: 713; 26. (37) de Bruin, *58*, **118**: 804; 26. (38) de Bruin, *96*, **44**: 157; 27. (39) de Bruin, *58*, **119**: 925; 27.
(40) de Bruin, *96*, **46**: 856; 28. (41) del Campo, *Trab. del Lab. invest. Fis. Univ. Madrid*, No. **68**; 23. (42) Carragan, *21*, **63**: 145; 26. (43) Carroll, *62*, **225**: 357; 26. (44) Catalán, *132*, **15**: 432; 17. (45) Catalán, *62*, **223**: 127; 22. (46) Catalán, *132*, **20**: 606; 22. (47) Catalán, *132*, **21**: 84; 23. (48) Catalán, *132*, **21**: 213, 527; 23. (49) Catalán, *132*, **21**: 321; 23.
(50) Catalán, *132*, **21**: 464; 23. (50.5) Catalán, *132*, **22**: 497; 24. (51) Catalán, *34*, **176**: 84; 23. (52) Catalán, *54*, **176**: 247, 1063; 23. (53) Catalán, *132*, **22**: 72; 24. (54) Catalán, *132*, **22**: 398; 24. (55) Catalán, *58*, **113**: 889; 24. (56) Catalán, *96*, **47**: 89; 28. (57) Catalán and Bechert, *96*, **32**: 336; 25. (58) Crookes, *5*, **95**: 438; 19. (59) Croze, *34*, **180**: 277; 25.
(60) Croze, *34*, **180**: 432; 25. (61) Croze and Mihul, *34*, **185**: 702; 27. (62) Dahmen, *88*, **6**: 19; 25. (63) Dahmen, *96*, **35**: 528; 26. (64) Datta, *5*, **99**: 69; 21. (65) Datta, *5*, **101**: 539; 22. (66) Dingle, *5*, **100**: 167; 21. (67) Dingle, *5*, **113**: 323; 26. (68) Dingle, *58*, **119**: 86; 27. (69) Dingle, *5*, **117**: 407; 28.
(70) Foote, Takamine and Chenault, *2*, **26**: 165; 25. (71) Foster, *2*, **23**: 667; 24. (72) Fowler, *21*, **21**: 81; 05. (73) Fowler, *520*, **73**: 62; 13. (74) Fowler, *5*, **89**: 133; 13. (75) Fowler, *62*, **214**: 225; 14. (76) Fowler, *B93*. (77) Fowler, *5*, **103**: 413; 23. (78) Fowler, *5*, **105**: 299; 24. (79) Fowler, *58*, **113**: 802; 24.
(80) Fowler, *62*, **225**: 1; 25. (81) Fowler, *5*, **107**: 31; 25. (82) Fowler, *5*, **110**: 476; 26. (83) Fowler, *5*, **117**: 317; 28. (84) Fowler and Freeman, *5*, **114**: 662; 27. (85) Fowler and Hartree, *5*, **111**: 83; 26. (86) Fowler and Reynolds, *5*, **89**: 137; 13. (87) Fowler and Selwyn, *5*, **118**: 34; 28. (88) Franck, *96*, **11**: 155; 22. (89) Frisch, *218*, **15**: 507; 27.
(90) Fues, *8*, **63**: 1; 20. (91) Gartlein, *2*, **29**: 357; 27. (92) Gibbs and White, *197*, **12**: 598; 26. (93) Gibbs and White, *2*, **29**: 426; 27. (94) Gibbs and White, *2*, **29**: 655; 27. (95) Gibbs and White, *2*, **29**: 917; 27. (96) Gieseler, *8*, **69**: 147; 22. (97) Gieseler, *96*, **22**: 228; 24. (98) Gieseler and Grotrian, *96*, **22**: 245; 24. (99) Gieseler and Grotrian, *96*, **25**: 165; 24.
(100) Gieseler and Grotrian, *96*, **25**: 342; 24. (101) Gieseler and Grotrian, *96*, **34**: 373; 25. (102) Gieseler and Grotrian, *96*, **39**: 377; 26. (103) Gieseler, *96*, **42**: 265; 27. (104) Götze, *8*, **66**: 285; 21. (105) Goudsmit, *58*, **113**: 238; 24. (106) Goudsmit, *218*, **12**: 851; 24. (107) Goudsmit, *64P*, **28**: 23; 25. (108) Goudsmit and Back, *96*, **43**: 321; 27. (109) Goudsmit, van der Mark and Zeeman, *64P*, **28**: 127; 25.

(110) Green and Loring, *2*, **30**: 574; 27. (111) Green and Petersen, *21*, **60**: 301; 24. (112) Grotrian, *96*, **8**: 116; 21. (113) Hagenbach, *149*, **1**: 231; 19. (114) Hagenbach and Schumacher, *3*, **71**: 19; 23. (115) Hansen, Takamine and Werner, *214*, **5**: No. 3; 23. (116) Hasbach, *99*, **13**: 399; 14. (117) Heisenberg, *96*, **33**: 879; 25. (118) Hicks, *3*, **38**: 1; 19. (119) Hicks, *A Treatise on the Analysis of Spectra*. Cambridge, Cambrige Univ. Press, 1922. (120) Hopfield, *58*, **112**: 437; 23. (121) Hopfield, *21*, **59**: 114; 24. (122) Hopfield, *2*, **26**: 282; 25. (123) Hopfield, *2*, **27**: 801; 26. (124) Hopfield and Dicke, *2*, **27**: 638; 26. (125) Hund, *B1*. (126) Ignatiev, *3*, **43**: 1117; 14. (127) Kayser and Runge, *3*, **41**: 302; 90. (128) Kayser and Runge, *3*, **43**: 385; 91. (129) Kayser and Runge, *3*, **46**: 225; 92. (130) Kayser and Runge, *3*, **48**: 126; 93. (131) Kayser and Runge, *3*, **52**: 114; 94. (132) Kent, *21*, **40**: 337; 14. (133) Kichlu, *96*, **39**: 572; 26. (134) Kichlu, *58*, **119**: 671; 27. (135) Kichlu, *58*, **120**: 549; 27. (136) Kiess, *31A*, **19**: 113; 23. (137) Kiess, *166*, **60**: 249; 24. (138) Kiess, *48*, **10**: 287; 25. (139) Kiess, *48*, **11**: 1; 25. (140) Kiess, *166*, **61**: 468; 25. (141) Kiess and Kiess, *166*, **56**: 666; 22. (142) Kiess and Kiess, *128*, **13**: 270; 23. (143) Kiess and Kiess, *532*, **31**: 647; 23. (144) Kiess and Kiess, *48*, **8**: 607; 24. (145) Kiess and Kiess, *48*, **14**: 140; 27. (146) Kiess and Laporte, *166*, **63**: 234; 26. (147) Koch, *3*, **43**: 98; 15. (148) Konen and Hagenbach, *63*, **4**: 592; 03. (149) Konen and Hagenbach, *63*, **4**: 801; 03. (150) Kuhn, *542*, **7**: No. 12; 26. (151) Landé, *63*, **22**: 417; 21. (152) Landé, *96*, **17**: 292; 23. (153) Landé and Heisenberg, *96*, **25**: 279; 24. (154) Lang, *21*, **64**: 167; 26. (155) Laporte, *218*, **11**: 779; 23. (156) Laporte, *63*, **24**: 510; 23. (157) Laporte, *96*, **23**: 135; 24. **26**: 1; 24. (158) Laporte, *218*, **13**: 627; 25. (159) Laporte, *2*, **25**: 886; 25. (160) Laporte, *197*, **12**: 496; 26. (161) Laporte and Lang, *2*, **30**: 378; 27. (162) Lau, *63*, **25**: 60; 24. (163) Lehmann, *3*, **5**: 633; 01. (164) Liebert, *3*, **56**: 589, 610; 18. (165) Lorenser, *Diss.*, Tübingen, 1913. (166) Loyarte and Williams, *63*, **28**: 383; 27. (167) Lyman, *21*, **23**: 181; 06. **43**: 89; 16. (168) Lyman, *58*, **104**: 314; 19. (169) Lyman, *58*, **110**: 278; 22. (170) Lyman, *21*, **60**: 1; 24. (171) Lyman, *58*, **114**: 641; 27. (172) Lyman and Saunders, *Bull. Amer. Phys. Soc.*, **1**: No. 3, 16; 25. (173) McLennan and McLay, *5*, **108**: 571; 25. (174) McLennan and McLay, *5*, **112**: 95; 26. (175) McLennan and McLay, *69*, **20 III**: 89; 26. (175.5) McLennan and McLay, *69*, **20 III**: 201; 26. (176) McLennan and McLay, *69*, **20 III**: 355; 26. (177) McLennan, McLay and McLeod, *3*, **4**: 486; 27. (178) McLennan and Shaver, *69*, **18 III**: 1; 24. (179) McLennan and Smith, *69*, **20 III**: 157; 26. (180) McLennan and Smith, *5*, **112**: 110; 26. (181) McLennan, Young and McLay, *69*, **18 III**: 57; 24. (182) McLennan, Young and McLay, *69*, **18 III**: 77; 24. (183) Majumdar, *96*, **39**: 562; 26. (184) Majumdar, *58*, **120**: 918; 27. (185) Meggers, *128*, **13**: 317; 23. **14**: 151; 24. (186) Meggers, *128*, **14**: 419; 24. (187) Meggers, *128*, **14**: 442; 24. (188) Meggers, *21*, **60**: 60; 24. (189) Meggers, *96*, **39**: 114; 26. (190) Meggers, *128*, **17**: 25; 27. (191) Meggers, *48*, **14**: 140; 27. (192) Meggers, *48*, **14**: 191; 27. (193) Meggers and Kiess, *48*, **12**: 417; 26. (194) Meggers, Kiess and Walters, *48*, **9**: 355; 24. (195) Meggers and Laporte, *166*, **61**: 635; 25. (196) Meggers and Laporte, *128*, **16**: 143; 26. (197) Meggers and Laporte, *2*, **28**: 642; 26. (198) Meggers and Moore, *128*, **15**: 207; 25. (199) Meggers and Peters, *21*, **50**: 56; 19. (200) Meggers and Walters, *31A*, **22**: 205; 27. (201) Meissner, *63*, **15**: 668; 14. (202) Meissner, *3*, **50**: 713; 16. (203) Meissner, *3*, **65**: 378; 21. (204) Meissner, *96*, **37**: 238; 26. (205) Meissner, *96*, **39**: 172; 26. (206) Meissner, *96*, **40**: 839; 27. (207) Mihul, *34*, **183**: 876; 26. (208) Mihul, *34*, **183**: 1035; 26. (209) Mihul, *34*, **184**: 89; 27. (210) Mihul, *34*, **184**: 874; 27. (211) Mihul, *34*, **184**: 1055; 27. (212) Millikan and Bowen, *58*, **114**: 380; 24. (213) Millikan and Bowen, *2*, **25**: 600; 25. (214) Mohler, *2*, **23**: 108; 24. (215) Morand, *34*, **178**: 1528, 1701, 1897; 24. (216) Narayan and Rao, *58*, **120**: 120; 27. (217) Narayan and Rao, *96*, **45**: 350; 27. (218) Nissen, *63*, **21**: 25; 20. (219) Nissen, *21*, **57**: 185; 23. (220) Ornstein and Burger, *96*, **26**: 57; 24. (221) Paschen, *3*, **27**: 537; 08. (222) Paschen, *3*, **29**: 625; 09. (223) Paschen, *3*, **30**: 746; 09. (224) Paschen, *3*, **33**: 717; 10. (225) Paschen, *3*, **35**: 860; 11. (226) Paschen, *3*, **36**: 191; 11. (227) Paschen, *3*, **40**: 602; 13. **42**: 840; 13. (228) Paschen, *3*, **50**: 901; 16. (229) Paschen, *3*, **60**: 405; 19. (230) Paschen, *3*, **63**: 201; 20. (231) Paschen, *3*, **71**: 142; 23. (232) Paschen, *3*, **71**: 537; 23. (233) Paschen, *in B3*, (234) Paschen and Götze, *B92*, (235) Paschen and Meissner, *3*, **43**: 1223; 14. (236) Popov, *Verh. d. Schw. Naturf. Gesell.*, **2**: 150; 13. (237) Popov, *3*, **45**: 147; 14. (238) Ramage, *5*, **70**: 303; 02. (239) Randall, *3*, **33**: 739; 10. (240) Rao, *67*, **39**: 150; 27. (241) Rao, *67*, **39**: 161; 27. (242) Richter, *218*, **15**: 266; 27. (243) Ritz, *3*, **12**: 264; 03. (244) Ritz, *63*, **9**: 521; 08. (245) Roshdestvenskii, *Verh. d. Opt. Inst. Petrograd*, **2**: No. 8; 21. (g-series). (246) Ruark, *21*, **58**: 46; 23. (247) Ruark, Foote and Mohler, *48*, **8**: 17; 24. (248) Ruark, Mohler, Foote and Chenault, *31A*, **19**: 463; 24. (249) Rudy, *143*, **202**: 659; 26. (250) Runge and Paschen, *21*, **3**: 4; 96. (251) Runge and Paschen, *3*, **61**: 641; 97. *21*, **8**: 70; 98. (252) Runge and Paschen, *21*, **14**: 49; 01. *3*, **5**: 725; 01. (253) Russell, *58*, **113**: 163; 24. (254) Russell, *21*, **64**: 194; 26. (255) Russell, *2*, **31**: 27; 28. (256) Russell and Meggers, *2*, **29**: 606; 27. (257) Russell and Saunders, *21*, **61**: 38; 25. (258) Rydberg, *468*, **23**: No. 11; 90. (259) Rydberg, *3*, **50**: 625; 93. (260) Saha, *3*, **4**: 223; 27. (261) von Salis, *3*, **76**: 145; 25. (262) Saltmarsh, *3*, **47**: 874; 24. (263) Saunders, *21*, **20**: 188; 04. (264) Saunders, *2*, **20**: 117; 05. (265) Saunders, *21*, **21**: 195; 05. (266) Saunders, *21*, **28**: 223; 08. (267) Saunders, *21*, **32**: 153; 10. (268) Saunders, *21*, **50**: 151; 19. (269) Saunders, *21*, **51**: 23; 20. (270) Saunders, *21*, **52**: 265; 20. (271) Saunders, *21*, **56**: 73; 22. (272) Saunders, *197*, **12**: 556; 26. (273) Saunders, *2*, **27**: 799; 26. (274) Saunders, Harvard University, *O*. (275) Sawyer, *218*, **15**: 765; 27. (276) Sawyer and Beese, *58*, **116**: 936; 25. (277) Sawyer and Beese, *166*, **64**: 44; 26. (278) Sawyer and Paschen, *3*, **84**: 1; 27. (279) Sawyer and Smith, *2*, **29**: 357; 27. (280) Schüler, *218*, **12**: 579; 24. (281) Schüler, *3*, **76**: 292; 25. (282) Schüler, *96*, **37**: 568; 26. (283) Shenstone, *3*, **49**: 951; 25. (284) Shenstone, *2*, **28**: 449; 26. (285) Shenstone, *166*, **63**: 641; 26. (286) Shenstone, *2*, **29**: 380; 27. (287) Shenstone, *2*, **30**: 255; 27. (288) Smith, *58*, **120**: 728; 27. (289) Sommer, *218*, **13**: 840; 25. (290) Sommer, *96*, **37**: 1; 26. (291) Sommer, *96*, **39**: 711; 26. (292) Sommer, *96*, **45**: 147; 27. (293) Sommer, *2*, **29**: 358; 27. (294) Sommerfeld, *3*, **51**: 1; 16. (295) Sommerfeld, *3*, **63**: 221; 20. (296) Sommerfeld, *3*, **70**: 32; 23. (297) Sommerfeld, *208*, **4**: 115; 24. (298) Sommerfeld, *B94*. (299) Sponer, *96*, **32**: 19; 25. (300) Stark, *3*, **56**: 577; 18. (301) Stücklen, *96*, **34**: 562; 25. (302) Sugiura, *51*, **6**: 323; 25. (303) Sur, *58*, **114**: 611; 24. (304) Sur, *58*, **117**: 380; 26. (305) Sur, *3*, **2**: 633; 26. (305.5) Sur, *3*, **3**: 736; 27. (306) Sur, *96*, **41**: 791; 27. (307) Thorsen, recalculated from (116). (308) Thorsen, *218*, **11**: 78; 23. (309) Thorsen, *218*, **11**: 500; 23. (310) Thorsen, *218*, **12**: 705; 24. (311) Thorsen, *96*, **40**: 642; 26. (312) Toshnivall, *3*, **4**: 774; 27. (313) Tschulanowsky, *96*, **16**: 300; 23. (314) Uhler and Tanch, *21*, **55**: 291; 22. (315) Walters, *128*, **13**: 243; 23. (316) Walters, *128*, **14**: 407; 24. (317) Walters, *48*, **8**: 245; 24. (318) Walters, *128*, **15**: 88; 25. (319) Wentzel, *96*, **19**: 53; 23. (320) Werner, *in* (21). (321) Werner, *58*, **116**: 574; 25. (322) Werner, *58*, **118**: 154; 26. (322.5) Werner, *Diss.*, Copenhagen, 1927. (323) Werner, University of Copenhagen, *O*. (324) Wiedemann, *3*, **38**: 1041; 12. (325) Wilhelmy, *3*, **80**: 305; 26. (326) Wolff, *3*, **42**: 825; 13. (327) Wood, *3*, **44**: 538; 22. (328) Wood and Fortrat, *21*, **43**: 73; 16. (329) Zeeman, *63*, **14**: 405; 13.

STRUCTURES OF THE OPTICAL SPECTRA OF ATOMS

W. F. MEGGERS

(For compilation of our knowledge in 1922 of regularities in line spectra, *see* (38, 59, 105); for atomic structure and its relation to spectra, *see* Vol. I, p. 47, and Emission of X-rays, Vol. VI; for term values for series in atomic spectra, *see* p. 392; for structure of band spectra of compounds, *see* p. 409.)

The most important features of any optical system may be represented by the values of two quantum numbers l and r; l indicating the type of term corresponding to the lowest atomic energy (normal or unexcited state), and r the maximum multiplicity of sub-levels occurring in the spectral terms. The types commonly denoted by S, P, D, F, G, . . . correspond to $l = 0$, 1, 2, 3, 4, . . . In the following table are given all the values of l and r which are now (February, 1928) definitely known. Presented for spectra of atoms in the order of increasing atomic number (Z), these data illustrate the *alternation* and *displacement* laws of spectroscopy as well as periodic regularities in the values of l and r.

TABLE 1.—VALUES OF THE QUANTUM NUMBERS (l, r) FOR THE OPTICAL SPECTRA OF ATOMS

Z = atomic number; values of l and r are given in the form r^l for the spectra of normal atoms (I) and of atoms in successive stages of ionization (II, III . . .), the values of l being those for the term of zero energy (normal state). There are no data for Z = 43, 59 to 73, 75, 84 to 87, and 89 to 92, inclusive. The sources from which the data were obtained are indicated in the paragraph following the table. The symbols of the elements are there arranged alphabetically, and the atomic numbers are printed as subscripts.

Z	(1)	I	II	III	IV	V	Z	(1)	I	II	III	IV	V	Z	(1)	I	II	III	IV	V
1	H	2					24*	Cr	$3, 5, 7^0$	$2, 4, 6$	5		3	47	Ag	2^0	1, 3			
2	He	$1, 3^0$	2				25*	Mn	$4, 6^0, 8$	$5, 7^0$	6			48	Cd	$1^0, 3$	2^0			
3	Li	2^0	3(?)				26	Fe	$3, 5^2, 7$	$4, 6^2$				49	In	2^1	3	2		
4	Be	3^0	2				27	Co	$2, 4^3, 6$	3, 5				50	Sn	$1, 3^1$	2	3	2	
5	B	2^0	$1^0, 3$	2^0			28	Ni	$1, 3^3, 5$	2, 4				51	Sb	$2, 4^0$				2
6	C	1, 3	$2^1, 4$	3	2		29	Cu	$2^0, 4$	1, 3				52*	Te	1, 3				
7	N	2, 4	1, 3	2	3		30	Zn	$1^0, 3$	2^0	$1^0, 3$			53	I	2				
8*	O	$3^1, 5$	2	3, 5	2	3	31	Ga	2^1	3	2			54	Xe	†				
9	F	2, 4	3, 5	2	3		32	Ge	†			2		55	Cs	2^0	†			
10	Ne	$1^0, 3$	2, 4				33	As	$2, 4^0$					56	Ba	$1^0, 3$	2			
11	Na	2^0	†				34	Se	$3^1, 5$					57	La	$2^2, 4$	$1, 3^3$	2		
12	Mg	$1^0, 3$	2^0				35	Br	2					58	Ce				2	
13	Al	2^1	$1^0, 3$	2^0			36	Kr	†	†				74	W	$5^2, 7$				
14	Si	$1, 3^1$	$2^1, 4$	$1^0, 3$	2^0		37	Rb	2^0	†				76	Os	†				
15	P	2	3	2, 4	3	2	38	Sr	$1^0, 3$	2^0				77	Ir	†				
16	S	$3^1, 5$					39	Yt	$2^1, 4$	$1^0, 3$	2^2			78	Pt	1, 3				
17	Cl	2	3, 5	2, 4	3	2, 4	40	Zr	$1, 3^3, 5$	$2, 4^3$		2		79	Au	2^0				
18	A	$1^0, 3$					41	Cb	4, 6	5^2				80	Hg	$1^0, 3$	2^0			
19	K	2	1, 3				42	Mo	$5, 7^0$	$4, 6^0$				81	Tl	2^1		2		
20	Ca	$1^0, 3$	2				44	Ru	$3, 5^3$					82	Pb	$1, 3^1$	2^1		2	
21	Sc	$2^2, 4$	$1, 3^2$	2^2			45	Rh	$4^3, 6$					83	Bi	$2, 4^0$				
22	Ti	$1, 3^3, 5$	$2, 4^3$	3^3	2^2		46	Pd	$1^0, 3, 5$	2				88	Ra		2^0			
23	V	$2, 4^3, 6$	$3, 5^2$	4	3	2														

* For *VI*, $r = 2$ for O_8, Cr_{24}, Te_{52}; for *VII*, $r = 2$ for Mn_{25}. † *See* literature reference in next paragraph.

SOURCES OF DATA

A_{18} *I* (42, 121, 149). Ag_{47} *I* (43, 69, 129), *II* (7, 106, 157). Al_{13} *I* (43, 69, 129), *II* and *III* (127, 151). As_{33} *I* (100, 107, 134). Au_{79} *I* (43, 69, 96, 129, 170). B_5 *I* (43, 129), *II* (20, 21, 152), *III* (17, 152). Ba_{56} *I* (43, 69, 85, 129, 144), *II* (43, 69, 129). Be_4 *I* (23, 43, 129), *II* (23). Bi_{83} *I* (63, 171, 172). Br_{35} *I* (173). C_6 *I* (43, 49.5, 129), *II* (14, 17, 20, 123), *III* (20, 21), *IV* (17). Ca_{20} *I* (43, 69, 85, 129, 144), *II* (43, 69, 129, 149.5). Cb_{41} *I* (109), *II* (114). Cd_{48} *I* (43, 69, 129, 133), *II* (43, 69, 129, 146). Ce_{58} *IV* (50). Cl_{17} *I* (26, 73, 173); *II* (16, 72, 128); *III*, *IV*, and *V* (16). Co_{27} *I* (35, 35.5, 120, 138), *II* (120). Cr_{24} *I* (33, 56), *II* (84, 115), *III* (53), *V* (54), *VI* (51, 52). Cs_{55} *I* (43, 69, 129), *II* (159). Cu_{29} *I* (6, 43, 69, 129, 154, 162), *II* (155). F_9 *I* (26, 27, 38, 39), *II* (14, 27), *III* and *IV* (14). Fe_{26} *I* (58, 88, 91, 108, 120, 123.5, 176), *II* (137). Ga_{31} *I* (43, 69, 129, 174), *II* (131), *III* (31, 87, 130, 131.5). Ge_{32} *I* (99), *IV* (31). Gl, *see* Be. H_1 *I* (43, 69, 129, 164). He_2 *I* (41, 43, 69, 75, 93, 129), *II* (43, 69, 129). Hg_{80} *I* (29, 43, 69, 105, 129, 150), *II* (31, 43, 69, 129). I_{53} *I* (173). In_{49} *I* (43, 69, 129, 174), *II* (131), *III* (31, 86, 87, 130, 131.5). Ir_{77} *I* (117). K_{19} *I* (43, 69, 129), *II* (25, 27, 37). Kr_{36} *I* (68, 168), *II* (77). La_{57} *I* (111, 113), *II* (61, 112, 113), *III* (50). Li_3 *I* (43, 69, 129), *II* (153, 166, 177). Mg_{12} *I* and *II* (43, 69, 129). Mn_{25} *I* (1, 32, 43, 69, 97, 129, 138, 180), *II* (1, 32, 97, 138, 180), *III* (53), *VII* (51, 52). Mo_{42} *I* (34, 79, 114, 178), *II* (114, 178). N_7 *I* (74, 80), *II* (14, 36, 44, 48), *III* (14, 17, 20), *IV* (20). Na_{11} *I* (43, 69, 129), *II* (126). Nb, *see* Cb. Ne_{10} *I* (2, 41, 43, 67, 69, 94, 95, 129), *II* (28, 78). Ni_{28} *I* (8, 12), *II* (120, 156). O_8 *I* (43, 69, 70, 71, 89, 129), *II* (14, 46, 49, 141), *III* (14, 47, 122), *IV* (14, 17, 20), *V* and *VI* (22). Os_{76} *I* (117). P_{15} *I* (147, 167), *II* (15), *III* (16, 124, 148), *IV* (20, 148), *V* (18). Pb_{82} *I* (3, 60, 65, 165, 169, 179), *II* (57), *IV* (31). Pd_{46} *I* (5, 10, 103 104, 117), *II* (103). Pt_{78} *I* (66, 117). Ra_{88} *II* (43, 69, 129). Rb_{37} *I* (43, 69, 129). *II* (132). Rh_{45} *I* (114, 117, 160, 163). Ru_{44} *I* (116, 117, 161). S_{16} *I* (30, 43, 69, 70, 73, 129). Sb_{51} *I* (100, 107), *V* (86). Sc_{21} *I* and *II* (143), *III* (51, 52, 158). Se_{34} *I* (43, 69, 70, 101, 129). Si_{14} *I* (43, 45, 76, 129), *II* (16, 127), *III* and *IV* (45). Sn_{50} *I* (4, 62, 64, 165, 181), *II* (125), *III* (131), *IV* (31, 86, 87, 130, 131.5). Sr_{38} *I* (43, 69, 85, 129, 144), *II* (43, 69, 129). Te_{52} *I*

(101), *VI* (86). Ti_{22} *I* (59, 82, 140), *II* (136, 139), *III* (142), *IV* (51, 52, 142). Tl_{81} *I* (43, 69, 129, 133), *III* (31). V_{23} *I* (11, 136, 138, 139), *II* (110), *III* (55), *IV* (54), *V* (51, 52). W_{74} *I* (13, 40, 90). Xe_{54} *I* (102). Yt_{39} *I* (114, 118, 119), *II* (114, 119), *III* (50). Zn_{30} *I* (43, 69, 129, 150, 165), *II* (43, 69, 129, 146), *III* (92). Zr_{40} *I* (81, 114), *II* (83, 114), *IV* (50).

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MOLECULAR CONSTANTS DERIVED FROM BAND SPECTRA OF DIATOMIC MOLECULES[1]

RAYMOND T. BIRGE

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INTRODUCTION

Among spectroscopists it is customary to use in place of the true frequency (in sec^{-1}) the "wave-number;" *i.e.*, the number of waves in one cm in a vacuum. As a matter of convenience, a frequency so indicated is often referred to as the "frequency in cm^{-1} units." Furthermore, on the quantum theory, certain quantities, such as a spectral line, are associated with both definite frequencies and definite amounts of energy, the numerical ratio of the energy to the frequency being the same in all cases. Hence it is often very convenient to express both the energy and the frequency by the same numerical magnitude, and for this the wave-number (in cm^{-1}) is always used. Throughout this report, in the symbolic expressions as well as in the tables, all quantities of the nature of either frequency or energy are expressed in such cm^{-1} units. The multiplication of such values by **c** ($=2.99796 \times 10^{10}$ cm sec^{-1}) gives the true frequencies (in sec^{-1}), and by **hc** ($=1.9658 \times 10^{-16}$ erg cm) gives the true energies (in ergs).

From spectral data it is possible to evaluate a set of energy levels for molecules, as well as for atoms. Certain relatively widely spaced levels in molecules seem to correspond to those

[1] Results prior to Dec., 1927.

known for atoms, and hence are similarly designated and are said to be related to the electronic configuration. A transition from one, often multiple, electronic configuration to another gives rise to an entire *system* of bands. Each type of transition is correlated with bands of a definite structure. For details, *see* (40, 41).

In addition to these levels of atomic type, diatomic molecules have two other sets of levels. One corresponds to the mutual vibration, and the other to the mutual rotation, of the two nuclei. To each electronic level corresponds a distinct set of vibrational levels. To a first approximation, the energy corresponding to the level of each member of such a set above the associated electronic level is obtained by giving successive positive integral values to n in the expression $n(\omega_0 - \omega_0 x n + \ldots)$; x is a positive constant. The frequency (ω) of vibration is obtained by differentiating this with respect to n; $\omega = \omega_0(1 - 2xn + \ldots)$. It varies with n; at the lowest level, that at which the amplitude and energy of vibration are vanishingly small, $n = 0$ and $\omega = \omega_0$. A transition from one vibrational level to another gives rise to a *single* band.

As ω is the derivative with respect to n of the expression for the vibrational energy, the heat of dissociation is $D = \int_0^{n_0} \omega dn$, where n_0 is the value of n for which $\omega = 0$. Hence, if the bands can be experimentally followed to $\omega = 0$, D can be determined from spectroscopic data. Usually this cannot be done, but Birge and Sponer (6) have found that, for the normal state of certain types of molecules, fairly trustworthy values of D can be obtained by assuming $\omega = \omega_0(1 - 2xn)$ throughout the range $n = 0$ to $n = n_0$; then $D = \omega_0^2/4\omega_0 x$. It seems that whenever an excited molecule is dissociated, one of the resulting atoms is also excited. If the amount of this excitation is known, it is possible to derive the value (D'') of D for the normal molecule from that (D') of the excited level (*see* Table 3).

To each vibrational level corresponds a distinct set of rotational levels. These account for the individual lines of a band. To a first approximation, the rotational energy, relative to the vibrational level, is $Bm^2(1 - m^2u^2 + \ldots)$; m is a function of the quantum number j, but, in general, is not quantized; for zero rotation, $m = 0$. Usually $BI = \mathbf{h}/8\pi^2\mathbf{c} = 27.70 \times 10^{-40}$ g cm, where I = moment of inertia of the molecule about an axis through its center of mass and perpendicular to the line joining its nuclei. B and I vary with the vibrational energy, and become B_0 and I_0 when that is zero; the corresponding nuclear separation is $r_0 = \sqrt{I_0/\mu}$, where $\mu = m_0m_1m_2/(m_1 + m_2)$. For multiple levels, like ^2P, B_0I_0 is not given accurately by $\mathbf{h}/8\pi^2\mathbf{c}$; *see* (22, 31).

If $I_0' > I_0''$ the band is degraded towards the red. As the vibrational energy increases, the direction of degradation of the bands of a system may reverse.

The relative positions of the energy levels of a molecule may be unambiguously determined from its band spectra, but the interpretation of these levels depends on theory. The new 1926 mechanics (N. M.) of Heisenberg and Schrödinger, and the old (1918–1926) quantum mechanics (O. M.) differ as regards the position of the true electronic level with reference to the observed lowest level of a given set of vibrational and rotational levels. Hence, in general, the derived constants also differ. All data in the following tables refer to O. M.; they may be converted to N. M. by the following relations, in which symbols referring to N. M. are indicated by a bar over them: $\bar{I}_0 = I_0(1 + u^2/2) \times (1 - \alpha/2B_0)$, $\bar{r}_0 = r_0(1 + u^2/4)(1 - \alpha/4B_0)$, $\bar{\omega}_0 = \omega_0(1 + x)(1 - \alpha/4\omega_0)$; $\overline{\omega_0 x} = \omega_0 x$, $\bar{\nu}_e = \nu_e + s'' - s'$ where $s = 0.5\omega_0(1 + 0.5x)$.

These transformation equations are based on the $Bj(j + 1)$ form of the rotational energy, in the N. M. Further refinements seem to indicate that the true form is $B(j + \frac{1}{2})^2$, and in that case the factors containing $u^2/2$, $u^2/4$, and $\alpha/4\omega_0$ should be omitted.

The value of α is known for only a few systems (for CN, NO, and AlO, $\alpha/B_0 = 0.01$; for H_2, $\alpha/B_0 = 0.04$), and is not given in the following tables; it is positive, and $\alpha/2B_0$ is of the order of 0.01; x is of the same order; neither is negligible; $u^2/2$ and $\alpha/4\omega_0$ are of the order of 10^{-4} to 10^{-6} and are negligible.

A full account of the quantum analysis of molecular spectra (O. M.) is given in (1); previous tables of constants derived from band spectra (1, 36, 37, 38); complete bibliography (36, 38, 38.1). The O. M. is used consistently in (36) and, excepting BO bands, in (1), and is normally used in (37, 38), but occasionally in these, N. M. values given by the original investigators are inadvertently copied.

SYMBOLS AND CONSTANTS

(The values used for **h**, **c**, and especially R differ from those given in Vol. I); *see* Introduction regarding units.

B — A quantity, of the nature of (length)$^{-1}$, related to the moment of inertia of the molecule in such a way that the rotational energy, relative to the vibrational level, is given to the first approximation by $Bm^2(1 - m^2u^2 + \ldots)$. It varies with the vibrational energy; $B = B_0 - \alpha n$. Usually $BI = \mathbf{h}/8\pi^2\mathbf{c} = 27.70 \times 10^{-40}$ g cm.

B_0 — Value of B when vibrational and rotational energies are each zero. For multiple levels like ^2P, $B_0I_0 \neq \mathbf{h}/8\pi^2\mathbf{c}$ (22, 31).

c — Velocity of light *in vacuo*; $\mathbf{c} = 2.99796 \times 10^{10}$ cm/sec.

D — Heat of dissociation of the molecule.

D', D'' — Value of D for upper state, for lower (in Table 3, normal) state, of molecule.

E_e — Wave-number = elevation of electronic energy above normal level. (In line spectra, the corresponding quantity is so defined as to indicate the depression of a given level below ionization.)

e — Electronic charge; $\mathbf{e} = 4.774 \times 10^{-10}$ cgs electrostatic unit.

e/hc — The reciprocal of the potential difference that corresponds to the transition that gives rise to radiation of wave-length λ is $\mathbf{e}\lambda/\mathbf{hc}$; $\mathbf{e/hc} = 2.428 \times 10^6$ cgse = 8100 volt^{-1} cm^{-1}.

h — Planck's constant of action; $\mathbf{h} = 6.557 \times 10^{-27}$ erg sec.

I — Moment of inertia of the molecule about the line through its center of mass and perpendicular to the line joining its two nuclei.

I_0 — Value of I when vibrational and rotational energies are zero.

I_0', I_0'' — Value of I_0 for upper state, for lower state, of molecule.

m — A parameter in the approximate expression, $Bm^2(1 - m^2u^2 + \ldots)$, giving the rotational energy relative to vibrational level. It is a function of j, the quantum number correlated with the resultant angular momentum of the molecule, but, in general, is not quantized.

m_0 — Mass of atom of unit atomic weight; $m_0 = m_H/1.0077 = 1.650 \times 10^{-24}$ g.

m_H — Mass of atom of hydrogen; $m_H = 1.663 \times 10^{-24}$ g.

m_1, m_2 — Atomic weights of the two atoms composing the molecule.

n — A positive and integral parameter in the equations expressing the vibrational frequency, $\omega = \omega_0(1 - 2xn + \ldots)$, and the vibrational energy, $n(\omega_0 - \omega_0 x n + \ldots)$, relative to the electronic level.

N. M. — New mechanics (1926–) of Heisenberg and Schrödinger.

O. M. — Old quantum mechanics (1918–1926).

R — Rydberg's wave-number = 109 678.3 cm^{-1}.

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Table 1.—Constants of Diatomic Molecules

These data are derived on the O. M. basis from the quantum analysis of band spectra; many have been recomputed, either directly from the observations or from the value of B_0; the former are indicated by an *r* and the latter by a *b* placed after the Lit. number. All assume that both vibrational and rotational energy are vanishingly small. Each line of the table refers to one system of bands, ν_e is the spacing of the two electronic levels involved. (O), (H), indicates that ν_e is derived from origin, from head, of the 0-0 band. The (H) values may be in error by 5 to 20 cm^{-1}, being too great for the R, and too small for the V, bands. After the value of $\omega_0 x$ is given the sign, if known, of the next higher term in the expression, $n(\omega_0 - \omega_0 x n + \ldots)$, for the vibrational energy. When only the first two vibrational levels are known, $\omega_0 - \omega_0 x$, $\doteq$ their resulting separation, is given in ( ). It is known [25] that I_0, and hence r_0, is essentially the same for each of the ^2P sublevels involved in the NO β-bands, and it is probable [*cf.* [22, 31]] that the same is true in other cases, the true value of I_0 in each case being essentially the mean of the two values here given. Symbols, p. 410. *See* p. 409. Unit of ν_e, ω_0, and $\omega_0 x$ = 1 cm^{-1} $\doteq$ 2.99796 × 10^{10} vibration sec^{-1}; of I_0 = 10^{-40} g cm^2 = 10^{-24} g $Å^2$; of r_0 = 10^{-8} cm = 1Å.

Name of band	Carrier	Shaded	ν_e	Upper ω_0'	Upper $\omega_0'x'$	Lower ω_0''	Lower $\omega_0''x''$	Lit.	Upper, I_0'	Lower, I_0''	Upper, r_0'	Lower, r_0''	Type	Lit.
Silver bromide	AgBr	R	31 387(H)			247.2	0.81	[13]r						
Silver	AgH	R	29 898(O)	(1490)		(1690)		[1]	4.57	4.38	1.665	1.630	$^1S - {}^1S$	[1]
Silver iodide	AgI	R	31 148(H)			205.8	0.56	[12]r						
Aluminum hydride	AlH	R	23 477.0(O)	(1082)		(1625.1)		[1]	4.58	4.41	1.690	1.658	$^1S - {}^1P$	[1]
Aluminum	AlO	R	20 635.3(O)	864.4	3.75	970	7.0	[1]	46.02	43.38	1.667	1.618	$^2S - {}^2S$	[1]*
Gold chloride *A*	AuCl	R	19 078.5(H)	311.3	0.70	381.5	1.30	[11]						
Gold chloride *B*	AuCl	R	19 396.8(H)	314.85	1.45	381.5	1.30	[11]						
Gold	AuH	R	27 342.1(O)	1630	79	2249.4	34.0	[1]	4.74	3.93	1.69	1.54	$^1S - {}^1S$	[1]
Gold	AuH	R	38 230.0(O)	(1548)		2249.4	34.0	[1]					$^1S - {}^1S$	
BO α-group	$B^{11}O$	R	23 647.5(O)	1248.5	10.6	1873.7	11.71	[1]†	19.62	15.68	1.3506	1.2074	$^2S - {}^2P_1$	[24]‡
			23 521.3(O)						20.03	15.68	1.3647	1.2074	$^2S - {}^2P_2$	
BO α-group	$B^{10}O$	R	23 639.3(O)	1286.3	11.7	1928.1	12.39	[1]†	18.53	14.81	1.3510	1.2078	$^2S - {}^2P_1$	[24]‡
			23 513.1(O)						.....	14.81	.....	1.2078	$^2S - {}^2P_2$	
BO β-group	$B^{11}O$	R	42 865.2(O)	1270.2	10.07	1873.7	11.71	[1]†	18.53	15.68	1.3126	1.2074	$^2S - {}^2S$	[1]§
BO β-group	$B^{10}O$	R	42 856.0(O)	1306.2	10.53	1928.1	12.39	[1]†	17.48	14.81	1.3121	1.2078	$^2S - {}^2S$	[1]§
BO "combination"	$B^{11}O$	V	19 343.9(O)	1270.2	10.07	1248.5	10.6	[1]†	18.53	20.03	1.3126	1.3647	$^2P_2 - {}^2S$	[1]‖
			19 217.7(O)							19.62		1.3506	$^2P_1 - {}^2S$	
BO "combination"	$B^{10}O$	V	19 342.9(O)	1306.2	10.53	1286.3	11.7	[1]†	17.48	.....	1.3121	.....	$^2P_2 - {}^2S$	[1]‖
			19 216.7(O)							18.53		1.3510	$^2P_1 - {}^2S$	
Barium fluoride	BaF	R	19 997.3(H)	452.9	1.75	465.0	1.85	[37, 38]					$^2S - {}^2P$	
Barium oxide	BaO	R	14 664(H)	510	2.7	664	1.5	[37, 38]						
Beryllium fluoride	BeF	R	33 215(H)	1157	8	1250	12	[1]						
			33 180(H)											
Beryllium oxide	BeO(?)	R	21 231.6(H)	1354	8.9	1465	12.7	[1]					$^1S - {}^1S$	
Bismuth oxide	BiO	R	22 196(H)	410	3	530	7	[37, 38]						
Bromine	Br_2	R	16 463(H)	151	1.82−	326.6	1.72	[33]r					$^1S - {}^1S$(?)	
Swan	C_2(?)	V	19 379.2(O)¶	1773.42	19.35	1629.88	11.67	[28]	15.84	17.03	1.265	1.311	$^3P - {}^3P$	[1]

* Using 26.96 for atomic weight of Al.

† In terms of O. M., the origins and nuclear separations are not the same for each isotope. For values in N. M., *see* [1].

‡ The two isotopes have essentially the same r_0, but different I_0; ^2P doublet is inverted.

§ Data for I_0'' and r_0'' are taken from α-group, final state; for I_0' and r_0', from initial state plus C_0 [38.5] of β-group.

‖ Data for I_0'' and r_0'' are taken from α-group, initial state; for I_0' and r_0', as in note §. The ^2P doublet is inverted [24].

¶ From [46].

TABLE 1.—(*Continued*)

Name of band	Carrier	Shaded	ν_e	Upper		Lower		Lit.	Upper, I'_0	Lower, I''_0	Upper, r'_0	Lower, r''_0	Type	Lit.
				ω'_0	ω'_0x'	ω''_0	ω''_0x''							
High pressure carbon	C_2(?)	V	22 972.7(H)			1537.3	11.88	(1)						
Triplet carbon	C+H(?)	R	15 540(O) 15 623(O)	1105	9.8	(1714)		(1)						
C + H (λ4300)	CH	V	23 163.3(O)	(2851)		(2797) and (2815)		(1)	1.90	1.95	1.11	1.13	$^2P - {}^2D$	(1)
C + H(λ3900)	CH	R	25 715(O)					(1)	2.21	1.95	1.20	1.13	$^2P - {}^2S$	(1)
Violet cyanogen	CN	V	25 797.8(O)	2143.9	20.25−	2055.64	13.75	(1)	14.140	14.647	1.151	1.172	$^2S - {}^2S$	(1)
Red cyanogen	CN	R	14 430(O?) 14 374(O?)	1728.5	13.5	2055.64	13.75	(1)					$^2S - {}^2P_1$ $^2S - {}^2P_2$	§
Fourth positive group of carbon	CO	R	64 765(H)	1499.0	17.24	2154.7	12.70	(1, 19)					$^1S - {}^1P$	
Ångstrom CO	CO	V	22 164(O)	2132	50	1499.0	17.24	(1, 19)	14.26	17.31	1.122	1.236	$^1P - {}^1S$	(1)
Third positive group of carbon	CO	V	35 300*(H)	(2214) (?)		1724.78	14.47	(1)					$^3P - {}^3S$	
3A bands of CO	CO	V	43 600†(H)	(2133)		1724.78	14.47	(2, 10)						
Cameron CO	CO	R	48 500‡(H)	1724.8	14.5	2154.7	12.70	(1, 19); *cf.* (2)					$^1S - {}^1P$	
$a' - X$ CO	CO	R	58 927(O)	1155	9	2154.7	12.70	(19)						
$F - X$ CO	CO	R(?)	99 730(O)	1914	198	2154.7	12.70	‖						
Infra-red CO	CO	R	Zero	2148	9.7	2148	9.7	(1)	14.9	14.9	1.15	1.15	^1S	(1)
First negative group of carbon	CO^+	R	45 637.7(O)	1697.8	24.33	2197.03	15.17	(1)	15.4	14.05	1.17	1.11	$^2S - {}^2S$	(1)
Comet-tail	CO^+	R	20 471.6(O) 20 346.1(O)	1550.46	14.07+	2198.6	15.00	(1)	17.7(?)	14.05	1.25(?)	1.11	$^2S - {}^2P_1$ $^2S - {}^2P_2$	(1)§
"Combination"	CO^+	V	25 285(O) 25 158(O)	1697.8	24.33	1550.46	14.07+	(1)					$^2P_2 - {}^2S$ $^2P_1 - {}^2S$	§
Carbon sulfide	CS	R	38 796.3	1062.2	10.05	1276.5	6.00	(26)					$^1S - {}^1P$	
Calcium fluoride	CaF	V	16 559(H) 16 485(H)	588.1	2.93	582.4	2.75	(37, 38)					$^2S - {}^2P$	
Calcium hydride *A*	CaH	R¶	14 472.20(O) 14 392.30(O)					(20)	6.77	6.56	2.04	2.01	$^2S - {}^2P_2$ $^2S - {}^2P_1$	(20)
Calcium hydride *B*	CaH	V	15 753.84(O)					(20)	6.29	6.56	1.97	2.01	$^2S - {}^2S$	(20)
Calcium hydride *C*	CaH	V	28 353.04(O)					(20)	5.64	6.56	1.86	2.01	$^2S - {}^2S$	(20)
Calcium oxide	CaO	R	23 057(H)	740	3.3	848	4	(37)						
Cadmium hydride	CdH	V	22 278(O) 23 279(O)			1374		(1)	4.647 4.594	5.201 5.201	1.679 1.669	1.776 1.776	$^2S - {}^2P_1$ $^2S - {}^2P_2$	(1)
Chlorine absorption	Cl_2	R	19 563(H)	185.5	4.83−	570	4.6	(33)r					$^1S - {}^1S$?	
Chromium oxide	CrO	R	16 520(H) 16 500(H)	742	9.5	891	6	(37, 38)						

* ν_e at least 5-fold, varying from 35 288 to 35 390.

† ν_e at least 5-fold, varying from 43 556 to 43 655.

‡ ν_e at least 5-fold, varying from 48 534 to 48 438; ω_0 and ω_0x are from 3rd and 4th positive groups.

§ The ^2P doublet is assumed inverted because for BO it is found (24) to be inverted.

‖ Hopfield and Birge (19) absorption system; ω''_0 is from 4th group. There are other new absorption systems from *X*-level to levels *b* and *B* (Table 2), to new levels *C*, *E*, *G*, and probably several higher ones; *cf.* Table 2.

¶ For small values of *j*, I'_0 being $> I''_0$; for higher values, *V*, I'_0 being $< I''_0$. The band sequences may degrade to V; *cf.* CuF.

TABLE 1.—(*Continued*)

Name of band	Carrier	Shaded	ν_e	Upper		Lower		Lit.	Upper, I'_0	Lower, I''_0	Upper, r'_0	Lower, r''_0	Type	Lit.
				ω'_0	ω'_0x'	ω''_0	ω''_0x''							
Copper bromide *A*	$Cu^{63}Br^{79}$	R	20 489.2(H)	295.12	1.008	312.70	0.800	(43)						
Copper bromide *A*	$Cu^{63}Br^{81}$	R	20 489.2(H)	293.50	0.997	310.98	0.791	(43)*						
Copper bromide *A*	$Cu^{65}Br^{79}$	R	20 489.2(H)	292.59	0.991	310.01	0.786	(43)*						
Copper bromide *A*	$Cu^{65}Br^{81}$	R	20 489.2(H)	290.95	0.980	308.28	0.778	(43)*						
Copper bromide *B*	$Cu^{63}Br^{79}$	R	23 029.3(H)	282.90	1.323	313.16	0.908	(43)						
Copper bromide *B*	$Cu^{63}Br^{81}$	R	23 029.3(H)	281.34	1.309	310.44	0.898	(43)*						
Copper bromide *B*	$Cu^{65}Br^{79}$	R	23 029.3(H)	280.47	1.300	310.42	0.892	(43)*						
Copper bromide *B*	$Cu^{65}Br^{81}$	R	23 029.3(H)	278.89	1.286	308.73	0.883	(43)*						
Copper bromide *C*	$Cu^{63}Br^{79}$	R	23 452.4(H)	294.78	1.423	313.83	0.888	(43)						
Copper bromide *C*	$Cu^{63}Br^{81}$	R	23 452.4(H)	293.16	1.407	312.10	0.878	(43)*						
Copper bromide *C*	$Cu^{65}Br^{79}$	R	23 452.4(H)	292.25	1.398	311.13	0.873	(43)*						
Copper bromide *C*	$Cu^{65}Br^{81}$	R	23 452.4(H)	290.61	1.383	309.39	0.863	(43)*						
Copper chloride *A*	$Cu^{63}Cl^{35}$	R	18 997.7(H)	407.9	1.90	415.7	1.90	(43)						
Copper chloride *B*	$Cu^{63}Cl^{35}$	R	20 479.7(H)	399.04	1.668	415.22	1.682	(43)						
Copper chloride *B*	$Cu^{65}Cl^{35}$	R	20 479.7(H)	396.84	1.649	412.93	1.664	(43)*						
Copper chloride *B*	$Cu^{63}Cl^{37}$	R	20 479.7(H)	392.05	1.610	407.94	1.624	(43)*						
Copper chloride *B*	$Cu^{65}Cl^{37}$	R	20 479.7(H)	389.81	1.591	405.62	1.605	(43)*						
Copper chloride *C*	$Cu^{63}Cl^{35}$	R	20 626.0(H)	397.45	1.654	415.53	1.648	(43)						
Copper chloride *C*	$Cu^{65}Cl^{35}$	R	20 626.0(H)	395.26	1.636	413.24	1.630	(43)*						
Copper chloride *C*	$Cu^{63}Cl^{37}$	R	20 626.0(H)	390.48	1 596	408.25	1.591	(43)*						
Copper chloride *C*	$Cu^{65}Cl^{37}$	R	20 626.0(H)	388.26	1.578	405.92	1.573	(43)*						
Copper chloride *D*	$Cu^{63}Cl^{35}$	R	22 961.7(H)	393.16	1.839	415.57	1.679	(43)						
Copper chloride *D*	$Cu^{65}Cl^{35}$	R	22 961.7(H)	390.94	1.819	415.28	1.656	(43)*						
Copper chloride *D*	$Cu^{63}Cl^{37}$	R	22 961.7(H)	386.27	1.775	408.29	1.616	(43)*						
Copper chloride *D*	$Cu^{65}Cl^{37}$	R	22 961.7(H)	384.07	1.755	405.96	1.597	(43)*						
Copper chloride *E*	$Cu^{63}Cl^{35}$	R	23 071.2(H)	404.07	1.818	414.90	1.278	(43)						
Copper chloride *E*	$Cu^{65}Cl^{35}$	R	23 071.2(H)	401.84	1.798	412.61	1.264	(43)*						
Copper chloride *E*	$Cu^{63}Cl^{37}$	R	23 071.2(H)	396.99	1.755	407.63	1.234	(43)*						
Copper chloride *E*	$Cu^{65}Cl^{37}$	R	23 071.2(H)	394.73	1.735	405.30	1.220	(43)*						
Copper fluoride *A*	$Cu^{63}F$	R†	17 556.7(H)	638.33	3.488	612.84	3.625	(43)						
Copper fluoride *B*	$Cu^{63}F$	R†	19 752.9(H)	647.62	3.725	612.84	3.625	(43)						
Copper fluoride *B*	$Cu^{65}F$	R†	19 752.9(H)	645.31	3.698	610.65	3.599	(43)*						
Copper fluoride *C*	$Cu^{63}F$	R†	20 270.0(H)	640.88	4.188	618.70	3.950	(43)						
Copper fluoride *C*	$Cu^{65}F$	R†	20 270.0(H)	638.59	4.158	616.49	3.922	(43)*						
Copper hydride	CuH	R	23 311.15(O)	1655.70	44.63	1903.68	37.36	(1)	4.097	3.544	1.582	1.471	$^1S - {}^1S$	(1)
Copper iodide *A*	$Cu^{63}I$	R	19 708.2(H)	211.05	2.215	264.93	0.719	(43)						
Copper iodide *B*	$Cu^{63}I$	R	21 748.3(H)	241.8	1.88	265.4	1.0	(1)						
Copper iodide *C*	$Cu^{63}I$	R	21 852.2(H)	229.17	0.528	263.90	0.728	(43)						
Copper iodide *D*	$Cu^{63}I$	R	22 931.6(H)	211.86	0.917	263.83	0.704	(43)						
Copper iodide *E*	$Cu^{63}I$	R	23 982.7(H)	228.28	0.954	263.81	0.671	(1)						
Fluorine	F_2	R	17 439(O)	1104.9(?)	2.9(?)	1071.5(?)	9.9	(17)‡		29‡		1.4	$^1S - {}^1S(?)$	(17)

* Calculated from observed bands of main (first listed) isotope of the system. (*E.g.*, $Cu^{63}Br^{79}$ is the main isotope of CuBr for each of the three systems, *A*, *B*, and *C*.) All systems of each molecule have the same lower level.

† CuF is the only known case for which band sequences degrade to V while bands degrade to R; *cf.* CaH, *A* bands.

‡ Analysis by Gale and Monk (16, 17) is very uncertain. An intercomparison of the halogens gives as more probable predicted values: ν_e = 23 000 to 25 000, ω'_0 = 320, ω'_0x' = 15 to 20, ω''_0 = 1170, ω''_0x'' = 10. Mecke (37) rightly gives I''_0 = 29, which is double their value, and checks with values for other halogens.

TABLE 1.—(*Continued*)

Name of band	Carrier	Shaded	ν_e	Upper ω'_0	Upper ω'_0x'	Lower ω''_0	Lower ω''_0x''	Lit.	Upper, I'_0	Lower, I''_0	Upper, r'_0	Lower, r''_0	Type	Lit.
Hydrogen *A-B* ultra-violet	H_2	R	90 083(O)	1325	15.9	4262	113.5	(3)	1.99	0.480	1.55	0.76	$1^1S - 2^1S$	(3)
Hydrogen *A-C* ultra-violet	H_2	R	99 086(O)	2380	66.5	4262	113.5	(3)	0.942	0.480	1.06	0.76	$1^1S - (?)$	(3)
Hydrogen *A*	H_2	V	21 573.8(O)	2373.8	12.36(?)	1325	15.9	(3)		1.99		1.55	$2^1S - 3^1P$	(3)
Hydrogen *B*	H_2	V	27 133.9(O)	2325.6(?)		1325	15.9	(3)		1.99		1.55	$2^1S - 4^1P$	(3)
Hydrogen $2^3P - 3^3S$	H_2	R	16 692.0(O)			2390	73	(3)		0.78		0.97	$2^3P - 3^3S$	(3)
Hydrogen α (Fulcher)	H_2	R	16 611.43(O)	2306.94	62.94	2593.82	68.41	(3)	1.072	0.965	1.136	1.08	$2^3S - 3^3P$	(3)
Hydrogen β	H_2	R	22 263.24(O)	2276.45	63.08	2593.82	68.41	(3)	1.089	0.965	1.145	1.08	$2^3S - 4^3P$	(3)
Hydrogen γ	H_2	R	24 839.05(O)	2251	58(?)	2593.82	68.41	(3)	1.135	0.965	1.168	1.08	$2^3S - 5^3P$	(3)
Hydrogen δ	H_2	R	26 224.21(O)	2229(?)	54(?)	2593.82	68.41	(3)	1.130	0.965	1.166	1.08	$2^3S - 6^3P$	(3)
Hydrogen ϵ	H_2	R	27 054.45(O)			2593.82	68.41	(3)		0.965		1.08	$2^3S - 7^3P$	(3)
Hydrogen ζ	H_2	R	27 592.52(O)			2593.82	68.41	(3)		0.965		1.08	$2^3S - 8^3P$	(3)
HBr near infra-red	HBr	R	Zero	2603	44	2603	44	(1, 7)*	3.303	3.303	1.418	1.418	^1S	(1)
HBr far infra-red	HBr		Zero	Zero		Zero			3.3180	3.3180	1.4213	1.4213	^1S	(8)*b*
HCl near infra-red	HCl	R	Zero	2940.8	53.6+	2940.8	53.6	(1, 30)†	2.645	2.645	1.279	1.279	^1S	(1)
HCl far infra-red	HCl		Zero	Zero		Zero			2.6593	2.6593	1.2823	1.2823	^1S	(8)*b*
HF near infra-red	HF	R	Zero	3987	50	3987	50	(1)‡	1.35	1.35	0.924	0.924	^1S	(1)
HF far infra-red	HF		Zero	Zero		Zero			1.3465	1.3465	0.9233	0.9233	^1S	(8)*b*
HI far infra-red	HI		Zero	Zero		Zero			4.3146	4.3146	1.6170	1.6170	^1S	(8)*b*
He_2 main *P* series (λ4648)	He_2	R	21 507.3(O)	(1643.5)		(1731.8)		(52)	3.861 3.900	3.650	1.082 1.087	1.052	$2^1S_m - 3^1P_m$	(40)*b*§
He_2 main *P* series (λ3676)	He_2	R	27 193.0(O)	(1627.8)		(1731.8)		(52)	3.879 3.976	3.650	1.084 1.098	1.052	$2^1S_m - 4^1P_m$	(40)*b*§
He_2 main *P* series (λ3356)	He_2	R	29 785.5(O)			(1731.8)		(52)	3.885 3.989	3.650	1.085 1.099	1.052	$2^1S_m - 5^1P_m$	(40)*b*§
He_2 main *P* series (λ3206)	He_2	R	31 180.0(O)	(1623.8)		(1731.8)		(52)	3.892 4.121	3.650	1.086 1.117	1.052	$2^1S_m - 6^1P_m$	(40)*b*§
He_2 main *P* series (λ3071)	He_2	R	32 556.8(O)			(1731.8)		(52)‖	3.895 4.168	3.650	1.086 1.124	1.052	$2^1S_m - 7^1P_m$	(40)*b*§
He_2 main *S* series (λ6399)	He_2	R	15 623.9(O)					(52)¶	3.84	3.784	1.079	1.071	$2^1P_m - 3^1S_m$	(40)*b*
He_2 main *S* series (λ4546)	He_2	R	21 992.8(O)					(52)¶	3.88	3.784	1.084	1.071	$2^1P_m - 4^1S_m$	(40)*b*
He_2 main *S* series (λ4030)	He_2	R	24 804(O)					(52)		3.784		1.071	$2^1P_m - 5^1S_m$	
He_2 main *D* series (λ5733)	He_2	V	17 436.6(O)					(52)	3.666	3.784	1.054	1.071	$2^1P_m - 3^1D_m$	(40)*b*
He_2 secondary *P* series (λ5133)	He_2	R	19 476.9(O)			(1790.1)		(52)	3.86 3.89	3.62	1.08 1.09	1.047	$2^1S_s - 3^1P_s$	(40)*b*§
He_2 secondary *P* series (λ4002)	He_2	R	24 978.6(O)			(1790.1)		(52)	3.90 3.97	3.62	1.09 1.10	1.047	$2^1S_s - 4^1P_s$	(40)*b*§
He_2 secondary *P* series (λ3634)	He_2	R	27 509.9(O)			(1790.1)		(52)	3.86 4.11	3.62	1.08 1.11	1.047	$2^1S_s - 5^1P_s$	(40)*b*§
He_2 secondary *P* series (λ3462)	He_2	R	28 875.0(O)			(1790.1)		(52)	3.86 4.20	3.62	1.08 1.13	1.047	$2^1S_s - 6^1P_s$	(40)*b*§
He_2 combination (λ600.13)	He_2	R	166 631(H)					(47)					$1^1S_s - 2^1S_s$	(47)**
Mercury hydride	HgH	V	24 933.9(O) 28 617.1(O)	(1940)		1 308 1 308	104− 104−	(1)††	4.220 4.181	5.143 5.143	1.597 1.589	1.763 1.763	$^2S - {}^2P_1$ $^2S - {}^2P_2$	(1)

* From 1st harmonic at $\lambda = 1.988\ \mu$ (7).

† Second overtone at $\lambda = 1.190\mu$ (45) indicates third term of ω_n is +; values of ω_0 and ω_0x from (30).

‡ From 1st harmonic at $\lambda = 1.27\mu$ (45).

§ Double values of I_0 are due to sigma-type doubling in *P*-levels.

‖ Two more ^1P series bands at $\nu_e = 32\ 926.4$ and $33\ 189.0\ cm^{-1}$; other constants unknown.

¶ The 1-1 band also observed.

** The assignment of this band is extremely doubtful.

†† Mecke's (37) values ($\omega'_0 = 2036.1$, $\omega'_0x' = 98.3$) are based on older and incorrect assumption that 28 617.1 cm^{-1} band is 0-0 band of short λ-system.

TABLE 1.—(*Continued*)

Name of band	Carrier	Shaded	ν_e	Upper ω_0'	Upper $\omega_0'x'$	Lower ω_0''	Lower $\omega_0''x''$	Lit.	Upper, I_0'	Lower, I_0''	Upper, r_0'	Lower, r_0''	Type	Lit.
Iodine	I_2	R	15 598.3(H)	127.2	0.834−	213.67	0.592−	(1)r	951.6	742.6	3.015	2.663	$^1S - {}^1S(?)$	(1)
Iodine monochloride	ICl	R	15 390(H)	176.3	3.025−	(382)		(17.5)r						
Near red potassium	K_2	R	15 368.6(H)	74.72	0.30	91.86	0.29	(15)r*	139.5	87.4	2.079	1.647	$^1S - {}^1P$	(15)
Magnesium fluoride	MgF	V	27 825.5(H)	713.5	3.80	684.1	3.70	(37, 38)						
Magnesium hydride	MgH	V	19 271(O)	1568.7	34.75	1462.2	31.25	(50)†	4.62	4.86	1.70	1.74	$^2S - {}^2P$	(51)
Manganese oxide	MnO	R	17 906(H)	758.9	10.2	836.7	5.05	(37, 38)						
N_2 1st positive group	N_2	V	9 518.59(H)	1718.40	14.437−	1446.46	13.929−	(1)r‡					$^3S - {}^3P$	
N_2 2nd positive group	N_2	V	29 653.1(H)	2018.66	26.047−	1718.40	14.437−	(1)	15.24	16.08	1.149	1.212	$^3P - {}^3P$	(1)
N_2 4th positive group	N_2	V	44 218(H)			1718.40	14.437−	(1)					$^3P - (?)$	
N_2 ultra-violet	N_2	R	68 957.0(H)	1679.2	13.845	2345.16	14.445	(1, 5)					$^1S - {}^1P$	
N_2 new ultra-violet	N_2	R	103 671.7(H)					(5)					$^1S - (?)$	
N_2 new ultra-violet	N_2	R	104 415.6(H)					(5)					$^1S - (?)$	
First negative group of nitrogen	N_2^+	V	25 565.9(O)	2392.3	22.8−	2187.4	16.3	(1)	13.35	14.41	1.075	1.117	$^2S - {}^2S$	(1)
Nitrogen hydride β	NH	R	29 750(O)					(31)		1.81		1.08	$^3S - {}^3P$	(31)
Third positive, or γ, of nitrogen	NO§	V	44 072(O) 44 193(O)	2352	13−	1888.31	13.88	(1)	14.05	16.35	1.068	1.152	$^2P_2 - {}^2S$ $^2P_1 - {}^2S$	(18)‖
β of nitrogen	NO§	R	45 486.12(O) 45 394.58(O)	1029.43 1030.88	7.460+ 7.455+	1802.12 1891.98	14.424+ 14.454+	(25)	24.80	16.29	1.418	1.150	$^2P_1 - {}^2P_1$ $^2P_2 - {}^2P_2$	(25)
δ nitric oxide	NO§	V	52 260(H)	2347 (approx.)		1888.31	13.88	(32, 34)¶						
ϵ nitric oxide	NO§	V	53 271(H)	2324	27	1888.31	13.88	(34)r**						
Green sodium	Na_2	R	20 301.7(H)	124.13	0.84	158.5	0.73−	(35); *cf.* (15)††	104.7	72.1	2.35	1.95	$^1S - {}^1P$	(15)
Red sodium	Na_2	R	15 006.7(H)	115.7	0.43	157.8	0.54	(15)‡‡					$^1S - {}^3P$	
Sodium hydride (λ4333)	NaH	V	23 099(O)					(27)r	3.597	5.111	1.503	1.791		(27)
Sodium hydride (λ4655)	NaH	V	21 544(O)					(27)r	3.206	4.067	1.419	1.598		(27)
Oxygen, atmospheric	O_2	R	13 122.97(O) 13 124.87(O)	1415.017	11.911−			(9)§§	19.928 19.757	19.262 19.143	1.229 1.223	1.208 1.204	$^3S - {}^1S(?)$	(9)b
Oxygen, Schumann-Runge	O_2	R	49 359.3(H)	708	12.4−	1565.37	11.375	(1)r	34.22		1.609		$^3S - {}^3S(?)$	(1)
Oxygen, first negative	O_2^+	R	38 308††(H) 38 108††(H)	885.2	13.7	1859.9‖‖	16.53	(1)					$^2P - {}^2P$	
Oxygen, second negative	$O_2^+(?)$	V	16 592.2(H)	1180.3	17.8	1026.1	11.1	(37, 38)¶¶						
Water vapor	OH	R	32 410(O)	3084.7	97.8	(3568.4)		(1, 23)	1.634	1.500	1.022	0.979	$^2P - {}^2S$	(1)***
Sulfur	S_2	R	32 140(H)	424.4	2.7	724.5	2.91	(44)						
Sulfur oxide	SO	R	36 890(H)	623	6	1094.6	6.3	(37, 38)						

* By a different analysis (42), $\nu = 16\,103 + 74n' - 90n''$.

† Changed to O. M.; Mecke (37, 38) gives values in N. M.

‡ Constants of (1) revised to agree with numbering of (41.5).

§ In spite of apparent numerical discrepancies, all 4 of NO systems have the same lower level.

‖ Values of I_0'' extrapolated from Guillery's I_2'', I_3'', I_4''.

¶ ν_e is mean of doublet; ω_0'' and $\omega_0''x''$ are from γ-bands.

** ν_e is mean of doublet.

†† Origin and head almost coincide.

‡‡ Data poor; lower level same as for green band.

§§ Lower level same as for Schumann-Runge bands.

‖‖ Undoubtedly too small, *see* (1).

¶¶ Origin and analysis very uncertain, *see* (38).

*** These values of I_0'' and r_0'' correct an accidental error in (1); *see also* (31).

TABLE 1.—(*Continued*)

Name of band	Carrier	Shaded	ν_0	Upper ω'_0	Upper $\omega'_0 x'$	Lower ω''_0	Lower $\omega''_0 x''$	Lit	Upper, I'_0	Lower, I''_0	Upper, r'_0	Lower, r''_0	Type	Lit.
Scandium oxide	ScO	R	16 561(H) 16 521(H)	867	8.7	967	3.8	(37, 38)						
Selenium	Se_2	R	27 307(H)	247.2	2.3	397.5	1.32	(44)						
Silicon fluoride α system	$Si^{28}F(?)$	R	22 880.5(H)	709.5	7.05	860.5	4.55	(29)	95.6	95.4	2.261	2.259		(29)
Silicon fluoride β system	$Si^{28}F(?)$	V	34 561.4(H)	1015.8	4.75	860.5	4.55	(29)						
Silicon nitride *A*	$Si^{28}N$	R	24 234.2(O)	1016.3	17.77+	1145.0	6.57	(1)	38.0	37.4	1.571	1.558	$^2S - {}^2S$	(39)*b*
Silicon nitride new	SiN(?)	R	26 676(H) 26 649(H)	694	3.3	1025.9	6.4	(39)					$^2P - {}^2P$	
Silicon oxide	SiO	R	42 643(H)	844	5.8	1236	6.0	(1)					$^1S - {}^1P$	
Tin chloride	SnCl	V	31 262.5(H) 33 622.6(H)	431.3 431.3	1.2 1.2	353.5 351.4	1.0 1.2	(1)					$^2P - {}^2S$	
Strontium fluoride	SrF	V	15 356.3(H) 15 076.6(H)	504.6	2.22	497.7	1.85	(37, 38)					$^2S - {}^2P$	
Strontium fluoride	SrF	R	17 302.6(H)	487.1	1.91	497.7	1.85	(37, 38)						
Strontium oxide	SrO	R	24 638(H)	516	3	648	3.9	(37, 38)						
Tellurium	Te_2	R	22 671(H)	163	1	250.4	0.53	(44)						
Titanium oxide (green)	TiO	R	19 349.34(H) 19 338.61(H)	833.3	4.55	1003.6	4.52	(4)						
Vanadium oxide	VO	R	17 424(H)	(852)		1008	6	(37, 38)						
Zinc hydride	ZnH	V	23 263.6(O) 23 594.0(O)			1552		(1)	3.874 3.708	4.234 4.234	1.538 1.505	1.608 1.608	$^2S - {}^2P_1$ $^2S - {}^2P_2$	(1)

SYMBOLS AND CONSTANTS.—(*Continued from p. 410*)

R Spectral band is degraded towards the red, and usually has sharp head on violet side. For such bands, $I_0' > I_0''$.

r Nuclear separation of the two atoms.

r_0 Value of r when vibrational and rotational energies are zero; $r_0 = \sqrt{I_0/\mu}$.

u Symbol for $2B_0/\omega_0$.

V Spectral band is degraded towards the violet, and usually has sharp head on red side. For such bands, $I_0' < I_0''$.

x A positive constant in equations for vibrational frequency and energy; *see* n.

α A positive constant in $B = B_0 - \alpha n$.

λ Wave-length *in vacuo*. (Either actual or, as in frequency limits, virtual.)

μ Symbol for $m_0 m_1 m_2/(m_1 + m_2)$.

ν Frequency, or term value, serving to specify an energy level.

ν_e A quantity that is experimentally the frequency of a certain line in a certain band, called the "origin of the band system," and is theoretically the spacing of two electronic energy levels.

ω Frequency of vibration of the molecule; $\omega = \omega_0(1 - 2xn + \ldots)$.

ω_0 Value of ω when energies of vibration and rotation are vanishingly small.

$\backsimeq$ Signifies equivalent to, or corresponding to.

TABLE 2.—ELECTRONIC ENERGY LEVELS OF MULTIPLE LEVEL MOLECULES

In most molecules only a few electronic levels are known, and their relative positions can be readily deduced from Table 1, the vibrational and rotational constants being, within limit of error, the same for each of the correlated systems of bands. Data for more involved cases are given below. The value of $\sqrt{R/\nu}$ is calculated from ionization potential, if known. In column 1 is given the accepted designation, if any, of the level. Symbols, p. 410 and Table 1. *See* p. 409. Unit of E_e, ω_0, and $\omega_0 x = 1$ cm^{-1}, for E_e $\backsimeq 1.965_8 \times 10^{-16}$ erg, for ω_0 and $\omega_0 x \backsimeq 2.99796 \times 10^{10}$ vibration sec^{-1}; of $I_0 = 10^{-40}$ g cm^2; of $r_0 = 10^{-8}$ cm.

1	E_e	ω_0	$\omega_0 x$	I_0	r_0	Type	$\sqrt{R/\nu}$
			B^{11}O (24)*				
X	0	1 873.7	11.71	15.68	1.2074	^2S	
A	23 521.3 23 647.5	1 248.5	10.6	20.03 19.62	1.3647 1.3506	$^2P_2$ $^2P_1$	
B	42 865.2	1 270.2	10.07	18.53	1.3126	^2S	
			CO (19); *cf.* (2)†				
X	0	2 154.7	12.70			^1S	0.9767
a	48 500§	1 724.8	14.5			^3P	1.2846‡
a'	58 927	1 155	9				1.3990
A	64 765	1 499.5	17.24	17.31	1.236	^1P	1.4781
b	83 825	(2214)				^3S	1.8767
B	86 929	2 132	50	14.26	1.122	^1S	1.9778
C	91 923	(2133)				^1S(?)	2.1817
c	92 093					^3S(?)	2.1898
E	92 923	(2134)					2.2306
F	99 730	1914	198				2.6830
G	105 266						3.3626
X'	114 966	2197	15.17	14.05	1.11	CO^+	∞
			CO^+ (1)				
X'	0	2197	15.17	14.05	1.11	^2S	
A'	20 346 20 471.6	1550.46	14.07+	17.7(?)	1.25(?)	$^2P_2$ $^2P_1$	
B'	45 637.7	1697.8	24.33	15.4	1.17	^2S	
			H_2 (3)				
A	0	4262	113.5	0.480	0.76	1^1S	0.9396
B	90 083	1325	15.9	1.99	1.55	2^1S	1.7920
	94 735‖	2390	73	0.78	0.97	2^3P	1.9281‖
	94 906.7	2593.82	68.41	0.965	1.08	2^3S	1.9337
	95 469‖					2^1P	1.9526‖

TABLE 2.—(*Continued*)

1	E_e	ω_0	$\omega_0 x$	I_0	r_0	Type	$\sqrt{R/\nu}$
			H_2.—(*Continued*)				
C	99 086	2380	66.5	0.942	1.06		2.0882
	111 427					3^3S	2.9261
	111 518.1	2306.94	62.94	1.072	1.136	3^3P	2.9365
	111 656.8	2373.89	12.36(?)			3^1P	2.9526
	117 169.9	2276.45	63.08	1.089	1.145	4^3P	3.9395
	117.216.9	2325.6(?)				4^1P	3.9526
	119 744.2	2251	58(?)	1.135	1.168	5^3P	4.941
	121 130.2	2229(?)	54(?)	1.130	1.166	6^3P	5.942
	121 961.0					7^3P	6.942
	122 498.3					8^3P	7.942
	124 237	2247	61.4	0.927	1.056	H_2^+	∞
			He_2 (52, 405, 47)¶				
	0					1^1S_g	0.743
	164 287.2	(1731.8)		3.650	1.052	2^1S_m	1.788
	166 630.6	(1790.1)		3.62	1.047	2^1S_g	1.853
	169 071.8			3.784	1.071	2^1P_m	1.928
	184 695.7			3.84	1.079	3^1S_m	2.810
	185 794.5	(1643.5)		3.861 3.900	1.082 1.087	3^1P_m	2.928
	186 107.5			3.86 3.89	1.08 1.09	3^1P_g	2.964
	186 508.4			3.666	1.054	3^1D_m	3.013
	191 064.6			3.88	1.084	4^1S_m	3.818
	191 480.2			3.879 3.976	1.084 1.098	4^1P_m	3.928
	191 609.2	(1627.8)		3.90 3.97	1.09 1.10	4^1P_g	3.965
	193 876					5^1S_m	4.812
	194 072.7			3.885 3.989	1.085 1.099	5^1P_m	4.928
	194 140.5			3.86 4.11	1.08 1.11	5^1P_g	4.966
	195 467.2	(1623.8)		3.892 4.121	1.086 1.117	6^1P_m	5.927
	195 505.6			3.86 4.20	1.08 1.13	6^1P_g	5.964
	196 304.1	621.9)		3.892 4.174	1.086 1.125	7^1P_m	6.928
	196 844.0			3.895 4.168	1.086 1.124	8^1P_m	7.928
	197 213.6					9^1P_m	8.930
	197 476.2					10^1P_m	9.928
	198 589					He_2^+	∞
			N_2 (1, 5, 6, 41.5)**				
X	0	2345.16	14.445			^1S	0.895
A	66 260††	1446.46	13.929−			^3S	1.246
a	68 957.0	1679.2	13.846−			^1P	1.271
B	75 778.6	1718.40	14.437−	16.98	1.212	^3P	1.340
b	103 671.7						1.817
c	104 415.6						1.838
C	105 431.7	2018.66	26.047−	15.24	1.149	^3P	1.867
D	119 996.6						2.548
X'	136 890	2187.4	16.3	14.41	1.117	N_2^+	∞
			NO (1, 18, 25, 32, 34)‡‡				
X	0	1892.12	14.424+	16.29	1.150	$^2P_1$	1.20020
	121	1891.98	14.454+			$^2P_2$	1.20116
A	44 193	2352	13−	14.05	1.068	^2S	1.85287
B	45 486.12 45 515.58	1029.43 1030.88	7.460+ 7.455+	24.80	1.418	$^2P_1$ $^2P_2$	1.89154 1.89246
C	52 260	2347 (approx.)					2.143
D	53 271	2324	27				2.190
X'	76 140					NO^+	∞

* In terms of O. M., the origin and nuclear separations are not the same for each isotope; note that here they have essentially the same r_0 but different I_0. For values in N. M., *see* (1).

† The upper level (*c*) of the 3Δ-bands at 92 093 is apparently different from the absorption level (*C*) at 91 923. *See also* Table 1, notes.

‡ At least 5-fold, ranging from 1.2840 to 1.2849.

§ At least 5-fold, ranging from 48 438 to 48 534.

‖ Calculated levels.

¶ All absolute values of E_e for He_2 are extremely uncertain, being based on the extremely doubtful assignment of the λ600 band to $1^1S_g - 2^1S_u$.

** Ionization potential assumed = 16.9 volt.

†† Assumed on basis of 8.18 volt (5) as corrected by (41.5).

‡‡ Assumed ionization potential = 9.4 volt.

TABLE 3.—HEATS OF DISSOCIATION

D', D'' = heat of dissociation of excited, of normal, molecule, as derived from spectroscopic data (*see* p. 410); many of the values have been recalculated by Birge from the original data. D_c'' = value based in whole or in part on chemical data. Probable error is often great. Each numerical value is the number of volts through which a single electron must run in order to acquire an amount of energy that is equal to the corresponding heat of dissociation. Unit = 8100 cm^{-1} per molecule = 1 electron volt per molecule = 2.306×10^4 g-cal_{15} per g-mole.

	D'	D''	D_c''
AgBr[13]		2.3*	2.6
AgI[12]		2.34*	2.0
Br_2[33]	0.387	1.96*	2.0
C_2(?)†		7.0	
CN		9.5	
CO[6]		11.2	10.8
CO^+[6]		9.8	
Cl_2[33]	0.233	2.54*	2.47
CsI[14, 49]		3.25*	3.34
H_2[3, 53]		4.42	4.2
H_2^+[3]		2.6	
HI[12]		2.9	3.0
HgH		0.4	
I_2[6]	0.547	1.532*	1.6
ICl[17.5]	0.30	2.20*	2.20
K_2[15]	0.57	0.89*	
KBr[14]		3.9*	
KCl[14]		4.5*	
KI[14]		3.25*	
N_2[6, 48]		11.7	11.4
N_2^+[6]		9	
NO[6]		7.9	8.3
Na_2[35]‡	0.57	0.98*	
NaBr[14]		3.9	
NaI[14, 49]		<3.2	3.0
O_2[6]	0.96‖	7.02*	6.5
O_2^+[6]		6.5	
S_2[44]	0.97	4.9	
Se_2[44]	0.44	3.6(?)	
Te_2[44]	0.42	2.8(?)	

* Deduced from D', *see* p. 410.
† Carrier of Swan bands.
‡ Green bands. *See also* [15].
‖ Schumann-Runge bands. Value of D' corrects an error in [6].

LITERATURE

(For a key to the periodicals see end of volume)

[1] Birge, *337*, **11**: No. 57, p. 69; 26. [2] Birge, *2*, **28**: 1157; 26. [3] Birge, *197*, **14**: 12; 28. *58*, **121**: 134; 28. [4] Birge and Christy, *0. 2*, **29**: 212; 27. [5] Birge and Hopfield, *0. 2*, **29**: 356; 27. [6] Birge and Sponer, *2*, **28**: 259; 26. [7] Brinsmade and Kemble, *197*, **3**: 420; 17. [8] Czerny, *96*, **44**: 235; 27. [9] Dieke and Babcock, *197*, **13**: 670; 27.
[10] Duffendack and Fox, *21*, **65**: 214; 27. [11] Ferguson, *58*, **120**: 298; 27. [12] Franck and Kuhn, *96*, **43**: 164; 27. [13] Franck and Kuhn, *96*, **44**: 607; 27. [14] Franck, Kuhn and Rollefson, *96*, **43**: 155; 27. [15] Fredrickson and Watson, *2*, **30**: 429; 27. [16] Gale and Monk, *21*, **59**: 125; 24. [17] Gale and Monk, *2*, **29**: 211; 27. [17.5] Gibson and Ramsperger, *2*, **30**: 598; 27. [18] Guillery, *96*, **42**: 121; 27. [19] Hopfield and Birge, *2*, **29**: 922; 27.
[20] Hulthén, *2*, **29**: 97; 27. [21] Hulthén and Nakamura, *58*, **119**: 235; 27. [22] Hund, *96*, **36**: 657; 26. [23] Jack, *5*, **115**: 373; 27. [24] Jenkins, *197*, **13**: 496; 27. [25] Jenkins, Barton and Mulliken, *2*, **30**: 150; 27. [26] Jevons, *5*, **117**: 351; 28. [27] Johnson, *2*, **29**: 85; 27. [28] Johnson, *62*, **226**: 157; 27. [29] Johnson and Jenkins. *5*, **116**: 327; 27.
[30] Kemble, *48*, **12**: 1; 26. [31] Kemble, *2*, **30**: 387; 27. [32] Knauss, *2*, **31**: 918; 28. [33] Kuhn, *96*, **39**: 77; 26. [34] Leifson, *21*, **63**: 73; 26. [35] Loomis, *2*, **29**: 607; 27. [36] Mecke, *63*, **26**: 217; 25. [37] Mecke, *96*, **42**: 390; 27. [38] Mecke and Guillery, *63*, **28**: 479, 514; 27. [38.1] Mörikofer, *in* Gehrcke, *Handbuch der physikalischen Optik*, II. Leipzig, Barth, 1927. [38.5] Mulliken, *2*, **25**: 259; 25. [39] Mulliken, *2*, **26**: 319; 25.
[40] Mulliken, *2*, **28**: 1202; 26. [41] Mulliken, *2*, **28**: 481; 26. **29**: 391, 637; 27. **30**: 138; 27. [41.5] Poetker, *2*, **30**: 812; 27. [42] Pringsheim, and Rosen, *96*, **43**: 519; 27. [43] Ritschl, *96*, **42**: 172; 27. [44] Rosen, *96*, **43**: 69; 27. [45] Schaefer and Thomas, *96*, **12**: 330; 23. [46] Shea, *2*, **30**: 825; 27. [47] Sommer, *197*, **13**: 213; 27. [48] Sponer, *96*, **41**: 611; 27. [49] Terenin, *96*, **44**: 713; 27.
[50] Watson, *2*, **27**: 801; 26. [51] Watson and Rudnick, *2*, **29**: 413; 27. [52] Weizel and Füchtbauer, *96*, **44**: 431; 27. [53] Witmer, *2*, **28**: 1223; 26.

MAGNETIC RESOLUTION OF SPECTRAL LINES

P. ZEEMAN

INTRODUCTION

Symbols used exclusively in the table are explained there; those used in the introduction are as follows, λ, **c**, **e**, **h**, $\mathbf{m}_0$ having their usual significance (Vol. I, p. 16):

- ν Wave-number corresponding to λ, $\nu = 1/\lambda$.
- π Designates components with electric vector parallel to H. In other connections, it has its usual significance, $\pi = 3.14159$.
- σ Designates components other than π-components.
- E Energy level, or term.
- g Landé's splitting factor.
- H Magnetic field intensity.
- j Inner quantum number.
- k Azimuthal quantum number.
- l Azimuthal quantum number, $l = k - 1$.
- m Magnetic quantum number.
- n Total (principal) quantum number.
- N Rydberg's series constant.
- o Normal resolution by magnetic field, $o = \mathbf{e}H/4\pi\mathbf{c}\mathbf{m}_0$; $o/H = 4.695 \times 10^{-5}$ cm^{-1} per gauss.
- R Term multiplicity.
- r Rotational quantum number.

In Bohr's theory [33], $\nu = (E_1 - E_2)/\mathbf{h}$, where E_1 and E_2 are the energy levels of two stationary states. An energy level in an atom is called a term. For a neutral atom, a term sequence is approximately given by $N/(n + a)^2$, where N is characteristic of the atom, a is an empirical constant, and $n = 1, 2, 3 \ldots$

According to the vector atomic model [98, 123, 124, 125, 126, 186, 219, 231, 238, 239] and the assumption that the moments of momentum of all rotary motions within the atom are quantized, an energy state, or level, is defined by certain quantum numbers:

1. The n in the term sequence. This was given by Bohr and is related to the size of the electron orbit.

2. The azimuthal quantum number (k) is related to the shape of the orbit, and is the moment of momentum of the individual electron in its orbit. If the atom contains more than one electron, the total orbital moment of momentum of the entire group is the quantized vector sum of the individual orbital moments.

Recently, k has been replaced by $l = k - 1$, and the vector sum of the l's is quantized and denoted by L. Terms corresponding to $l = 0, 1, 2$ are denoted by S, P, D, respectively, and the corresponding orbits by s, p, d.

3. The moment of momentum of the spin of each electron on its axis is also quantized and gives the quantum number r, the unit

quantum being ½ ($h/2\pi$). It is supposed that all electrons within an atom spin in the same plane, but not in the same sense. The resultant moment of momentum of the spin of all the electrons is denoted by R. The maximum term multiplicity is $2R + 1$.

4. The total moment of momentum of the whole atom is $J = L + R$. This is the inner quantum number j of Sommerfeld.

The number of electrons in each orbit defines the configuration of the atom and is indicated thus s^2p^2d, if there are 2 electrons each in the s- and p-orbits, and one in the d-orbit.

From these quantization rules and Pauli's selection rules, it is possible to predict the spectral structure which corresponds to a given configuration of the atom (100, 101). The general term symbol is a group of the quantum numbers written in the form $n^r k_j$, where k is commonly replaced by the S, P, D notation, already defined, and whenever j is an odd number of halves, it is replaced by $j + ½$. The last is for typographical simplicity.

Effect of External Magnetic Field (262). 1. *Normal Zeeman Effect.*—Zeeman (250) discovered that a magnetic field (H) splits a line into polarized components. When viewed at right angles to H there are 3 components; the central one (π-component) coincides with the unresolved line, and its electric vector is parallel to H; the outer (σ) components are equidistant from the central one and their electric vectors are perpendicular to H. When viewed along H there are only two components; these are in the same positions as the σ-components, and are circularly polarized in opposite directions. Various theoretical explanations have been given (33, 51, 129, 230, 250). On the quantum theory the effect of a magnetic field on a spectral term E is $\Delta E = hom$, or $\Delta\nu = om$, where, according to the vector model, the magnetic quantum number m is the projection of j upon the direction of H, and $o = eH/4\pi cm_0$ is the normal resolution. In combination with the selection rules and the polarization rule for m ($\Delta m = 0$ for π-component, $\Delta m = \pm 1$ for σ-component) this gives an explanation of the normal Zeeman effect.

2. *Anomalous Zeeman Effect.*—For large values of H, all lines exhibit the normal effect (183), but in weaker fields most lines are split into a greater number of components. This is known as the anomalous effect, of which there are many types. The type is the same for all lines of a spectral series, and for analogous lines of atoms which exhibit the same spectral structure (192). In every case the Zeeman pattern is quite symmetrical about the center, as to distance, polarization, and intensity, and the distances differ little from rational fractions of the normal resolution o (212). *See* Fig. 1. Hence the effect may be symbolized thus: ±[(1) (3) 5 7 **9**]/5, indicating, in this case, that ideally the line is split into 10 components, symmetrical about the center and at distances ⅕, ⅗, ⅘, 7/5, and 9/5 of the normal resolution o; that the π-components are the first and second, in ( ); and that the strongest components are the first and fifth, printed in bold-face. This symbolism is used in this report; for comparison with observed distances, which are frequently not rational fractions of o, the ratios are expressed decimally.

The formalistic theory of Landé (17) is quite successful in explaining the anomalous effect. On this theory, a magnetic field splits a term into $2j + 1$ magnetic sublevels having the magnetic quantum numbers $m = j, j - 1, \ldots, 1 - j, -j$. Generally the effect is anomalous and $\Delta\nu = ogm$, where g, Landé's splitting factor, measures the spacing of the magnetic sublevels. To represent the observations best, g must be determined in accordance with the matrix mechanics (99), giving $g = 1 + [j(j + 1) + r(r + 1) - k(k + 1)]/2j(j + 1)$. *See* Table 1.

For many atoms the Zeeman effect deviates markedly from the theoretical pattern so determined, g having values not given by the formula. These deviations appear to depend upon two factors. They increase with increasing atomic number, and for a given spectrum they are usually small for the lowest level and increase progressively as the level increases. In such cases it is supposed that the vector coupling is not normal (87). These terms are said to be anomalous. In several cases it is not possible to find the theoretical values of g for the individual terms, but Pauli (185) has shown that in all cases the sum of the g-values for all terms of the same j of a particular configuration is the same as the sum of the theoretical g-values (principle of permanence of the g-sum). All these rules are empirical; for the heavier atoms departures from them are possible and, when they occur, of importance in the interpretation of the mechanics of the atom.

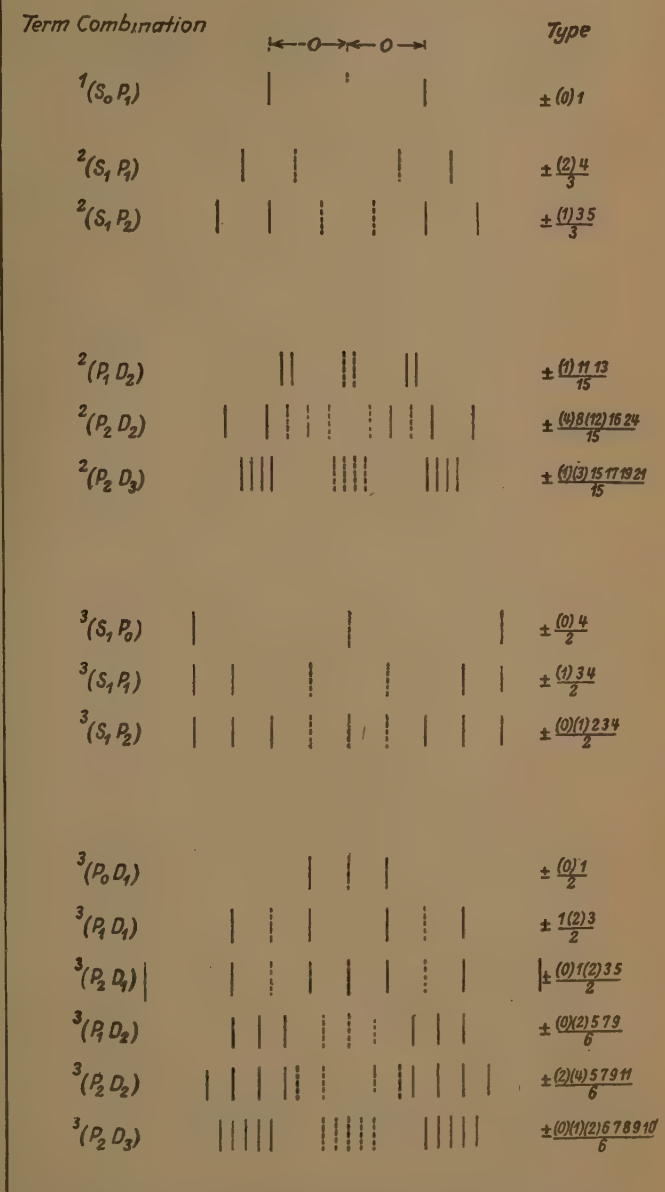

FIG. 1.—Schematic representation of the types of regular resolution of spectral lines. Dotted lines are π-components. Unit of displacement is that of the σ-components of the $^1(S_0P_1)$ lines.

TABLE 1.—VALUES OF LANDÉ'S SPLITTING FACTOR g

$$g = 1 + [j(j+1) + r(r+1) - k(k+1)]/2j(j+1)$$

k \ j	0	1	2	3	4	5	6	7	½	3/2	5/2	7/2	9/2	11/2	13/2	15/2	
0					Singlets				2					Doublets			S
1		1			$r = 0$				2/3	4/3				$r = \frac{1}{2}$			P
2			1							4/5	6/5						D
3				1							6/7	8/7					F
4					1							8/9	10/9				G
0			2		Triplets				2					Quartets			S
1	8/3	8/3	8/3		$r = 1$				8/3	16/9	8/3			$r = \frac{3}{2}$			P
2		4/3	7/3	4/3					0	8/9	40/27	10/9					D
3			8/3	11/3	5/3					8/5	36/25	7/5	9/5				F
4				5/3	20/9	8/3					9/7	45/28	11/7	13/7			G
0				2	Quintets					2				Sextets			S
1			5/2	11/5	5/2	$r = 2$				11/5	22/15	11/5		$r = \frac{5}{2}$			P
2	10/3	5/2	10/7	5/2	10/3				11/3	22/15	55/33	11/5	13/5				D
3		0	1	5/4	27/14	7/4			−5/3	16/15	44/33	88/55	143/65	13/7			F
4			1/3	11/12	22/15	13/12	4/3			0	8/9	11/9	143/99	13/9			G
0					2	Septets					2			Octets			S
1				7/3	28/15	7/4	$r = 3$				11/5	143/65	13/5		$r = \frac{7}{2}$		P
2		3	2	7/3	28/15	8/3				14/5	22/15	88/55	13/5				D
3	10/3	5/2	10/7	5/2	10/3	5/2	10/3		4	2	11/5	22/15	88/55	286/143	26/13		F
4		−1/3	8/9	7/6	13/9	44/30	52/42	10/9	−4/3	16/15	44/33	88/55	130/66	286/143	286/156	22/13	G
$\Delta\nu$ =			1 : 2 : 3 : 4 : 5 : 6 : 7						3/2 : 5/2 : 7/2 : 9/2 : 11/2 : 13/2 : 15/2								

TABLE 2.—BIBLIOGRAPHIC INDEX OF ELEMENTS FOR WHICH THE ZEEMAN EFFECT HAS BEEN INVESTIGATED

The atomic number is written as a subscript to the chemical symbol. (The following have not yet (Jan., 1928) been investigated: Ac_{89}, As_{33}, Cp_{71}, Cs_{55}, Dy_{66}, Em_{86}, Er_{68}, Eu_{63}, Ga_{31}, Gd_{64}, Ge_{32}, Hf_{72}, Ho_{67}, In_{49}, Lu_{71}, Ma_{43}, Nd_{60}, Nt_{86}, P_{15}, Pa_{91}, Po_{84}, Pr_{59}, Rb_{37}, Re_{75}, Rn_{86}, S_{16}, Sa_{62}, Se_{34}, Ta_{73}, Tb_{65}, Te_{52}, Tu_{69}, U_{92}, Xe_{54}, Yb_{70}.)

A_{18} (30, 58, 132, 135, 136, 154)
Ag_{47} (21, 23, 154, 155, 199, 200, 216)
Al_{13} (184, 205, 216)
Au_{79} (1, 95, 136, 154, 155, 169, 194, 199, 200)
B_5 (188)
Ba_{56} (5, 7, 8, 10, 160, 161, 189, 191, 216, 220)
Be_4 (10, 106, 107, 188)
Bi_{83} (94, 137, 194, 199, 200, 240)
Br_{35} (30, 113, 206)
C_6 (68, 72, 154, 155, 205)
Ca_{20} (12, 21, 106, 107, 158, 163, 178, 179, 184, 189, 205, 216, 260)
Cb_{41} (104, 105)
Cd_{48} (2, 7, 8, 44, 65, 109, 137, 154, 155, 158, 177, 178, 179, 184, 190, 191, 198, 204, 205, 208, 210, 216, 221, 222, 232, 240, 251, 252)
Ce_{58} (121, 143)
Cl_{17} (114)
Co_{27} (88, 109, 220)
Cr_{24} (3, 5, 6, 7, 8, 56, 57, 61, 62, 76, 79, 95, 116, 136, 156, 157, 198, 200, 202, 207, 261)
Cu_{29} (1, 10, 22, 61, 62, 95, 136, 154, 155, 165, 169, 191, 199, 200, 216, 228, 251)
F_9 (35, 36)
Fe_{26} (2, 5, 6, 7, 21, 25, 26, 27, 55, 88, 95, 109, 116, 117, 118, 120, 136, 152, 153, 154, 155, 172, 204, 205, 235, 249, 253, 254, 260)
Gl_4 (*See* Be)
H_1 (30, 31, 45, 46, 47, 48, 49, 53, 54, 63, 66, 154, 155, 176, 183)
He_2 (30, 50, 89, 90, 93, 132, 133, 134, 154, 155, 159, 164, 165, 183, 201)
Hg_{80} (18, 19, 20, 30, 32, 77, 78, 83, 84, 85, 89, 90, 106, 107, 109, 132, 133, 137, 138, 140, 142, 154, 155, 165, 166, 167, 170, 171, 174, 178, 179, 205, 209, 211, 213, 214, 215, 216, 222, 244, 247, 254, 255, 256, 257, 258, 260)
I_{53} (30, 135, 248)
Ir_{77} (197)
K_{19} (34, 183)
Kr_{36} (132, 133)
La_{57} (220)
Li_3 (13, 69, 110, 154, 155, 183, 259, 260)
Mg_{12} (1, 2, 12, 43, 44, 59, 106, 107, 154, 155, 158, 169, 178, 179, 198, 204, 205, 208, 210, 216, 237)
Mn_{25} (5, 11, 13, 76, 135, 136, 154, 155, 157, 158, 191, 198, 200)
Mo_{42} (5, 41, 102, 103, 245)
N_7 (9, 30, 45, 49, 52, 68, 71, 72, 73, 74, 195, 196)
Na_{11} (10, 13, 44, 69, 70, 71, 73, 74, 120, 122, 132, 133, 154, 155, 166, 183, 188, 191, 201, 208, 216, 221, 222, 246, 252, 259, 260, 263)
Nb_{41} (*See* Cb)
Ne_{10} (14, 132, 133, 165, 168, 173, 201, 236)
Ni_{28} (5, 12, 21, 88, 109, 136, 173, 187, 205, 225, 235, 249)
O_8 (47, 49, 75, 156, 180, 183)
Os_{76} (160, 161)
Pb_{82} (15, 94, 194, 199, 200)
Pd_{46} (21, 130, 131, 136, 187, 193, 195, 200)
Pt_{78} (97, 139, 151, 197, 200)
Ra_{88} (217)
Rh_{45} (193, 195, 200, 229)
Ru_{44} (150, 193, 195, 226, 227)
Sb_{51} (94, 194, 199, 200)
Sc_{21} (86)
Si_{14} (205)
Sn_{50} (16, 91, 92, 94, 154, 155, 194, 199, 200, 251)
Sr_{38} (106, 107, 158, 163, 189, 216)
Th_{90} (5, 44, 121, 122, 162)
Ti_{22} (5, 7, 8, 25, 115, 116, 117, 118, 198, 200, 218)
Tl_{81} (10, 154, 155, 208, 216, 240)
V_{23} (3, 4, 5, 6, 7, 120, 145, 197, 200)
W_{74} (5, 28, 57, 102, 103, 121, 233)
Yt_{39} (5, 160, 161, 189, 220)
Zn_{30} (2, 7, 44, 59, 65, 67, 73, 74, 109, 154, 155, 158, 177, 178, 179, 184, 191, 198, 204, 205, 208, 210, 216, 221, 222, 232, 240, 241, 242, 243, 249, 251)
Zr_{40} (160, 161)

TABLE 3.—ZEEMAN EFFECT FOR CU, MN, MO, NE, PB, RH, SC, SN, V, AND W

For explanation of type notation, *see* p. 418. Unit of displacement is $o = eH/4\pi cm_0$; $o/H = 0.04695$ cm^{-1} per kilogauss. B = broad; $2B_o$, $2B_c$ = observed, calculated, overall breadth of the resolved line = sum of the displacements of the extreme components: d, D = diffuse, very diffuse; f = displacement of strongest σ-component from undisturbed line; $g_z[g_y]$ = value of g for the first [second] term named in the term combination given in the "Term" column; Int. = intensity; Q_p = pseudoquartet; r, R, (in column Int.) = easily, very easily, reversed; r (in column 4) = completely resolved into all expected components; s, S = sharp, very sharp; s_i, s_o = sharp inside, outside; T, T_p = triplet, pseudotriplet; Ts = sharp triplet; w = weak, but all components could be measured; W = very weak; Z_o, Z_c = displacements of components as observed, as calculated; π-components (electric vector parallel to H) are in ( ); the displacement of the most intense member of each class (π, σ) is printed in bold face. Unit of λ = 1Å = 10^{-8} cm; of displacement = 0.04695 cm^{-1}/kilogauss.

Cu_{29} (22, 228); Int. and λ (64); Terms (228); term structure (22, 223, 224, 228, 234); references are given in column (4)

Int.	λ	Terms	4	Type
		Cu *I*		
3	5554.94	$^4D'_3 - {}^4D_4$	(22)	
	Z_o (0.00)	1.88		
	Z_c (0.03) (0.09) (0.14) 1.29 1.34 1.40 1.46 1.51 1.57			
1	5352.68	$^2F_3 - {}^4D_4$	(228)	
	Z_o **(0.00)**	2.15		
	Z_c **(0.29)** (0.86) (1.43) **2.86** 2.28 1.72 1.14 0.57 0.00			

Cu_{29}.—(*Continued*)

Int.	λ	Terms	4	Type
		Cu *I.*—(*Continued*)		
8R	5292.55	$^4D'_4 - {}^4D_4$	(228)	Z_o (0.00) 1.42; Z_c (0.00) 1.43
200	5218.20	$^2P_2 - {}^2D_3$	(228)	
	Z_o (**0.00**) **1.01**			
	Z_c (**0.07**) (0.20) **1.00** 1.14 1.27 1.40			
1*d*	5200.95	$^2F_3 - {}^4D_3$	(228)	
	Z_o (0.00) 0.73			
	Z_c (0.26) (0.77) (**1.28**) 2.15 1.62 **1.12** 0.60 0.09			
100	5153.26	$2^2P_1 - 3^2D_2$	(228)	Z_o (**0.00**) **0.89**; Z_c (**0.07**) 0.73 **0.87**
1	5111.94	$^4D'_4 - {}^4D_4$	(228)	$Z_o = Z_c$ (0.00) 0.00
50	5105.58	$^2D_3 - 2^2P_2$	(228)	
	Z_o (0.00) 1.10			
	Z_c (**0.07**) (0.20) **1.00** 1.14 1.27 1.40			
2	5016.63	$^4D'_2 - {}^4D_1$	(228)	Z_o (**0.54**) **1.63** 0.54; Z_c (**0.60**) **1.80** 0.60
1	4797.07	$^4F_3 - {}^4D_4$	(228)	
	Z_o (**0.00**) **2.05**			
	Z_c (**0.20**) (0.60) (1.00) **2.43** 2.03 1.63 1.23 0.83 0.43			
1*d*	4767.5	$^2D_2 - {}^2D''_2$	(228)	Z_o (0.00) 0.69; Z_c (0.00) 0.80
	4704.60	$^4F_4 - {}^4D_4$	(228)	
	Z_o (**0.65**) **1.42**			
	Z_c (0.10) (0.29) (0.48) (**0.67**) 0.76 0.95 1.14 **1.34** 1.53 1.72 1.91			
1	4651.13	$^4F_5 - {}^4D_4$	(228)	
	Z_o (**0.00**) 1.30			
	Z_c (**0.05**) (0.14) (0.24) (0.33) **1.00** 1.10 1.19 1.28 1.38 1.48 1.57			
20	4586.97	$^4F_4 - {}^4D_3$	(228)	
	Z_o (0.00) **0.88**			
	Z_c (0.07) (0.20) (0.33) **0.90** 1.04 1.17 1.31 1.41 1.57			
15	4530.84	$2^2P_2 - 3^2S_1$	(228)	Z_o (**0.33**) **1.00** 1.69; Z_c (**0.33**) **1.00** 1.67
4	4509.40	$^4F_2 - {}^4D_1$	(22)	Z_o (0.23) 0.23 0.64; Z_c (0.20) 0.20 0.60
8	4509.39	$^4F_2 - {}^4D_2$	(228)	Z_o (**0.21**) **0.45**; Z_c (**0.20**) **0.60** 0.20
10	4480.38	$2^2P_1 - 3^2S_1$	(228)	Z_o (0.65) 1.33; Z_c (0.67) 1.33
20	4275.13	$^4P_3 - {}^4D_4$	(228)	
	Z_o (0.00) **1.13**			
	Z_c (**0.09**) (0.26) (0.43) **1.00** 1.17 1.34 1.52 1.69 1.86			
1*d*	4253.34	$^4F_4 - {}^2D'_3$	(228)	
	Z_o (0.00) 1.14			
	Z_c (**0.02**) (0.06) (0.10) **1.34** 1.30 1.26 1.22 1.18 1.14			
8	4248.97	$^4P_1 - {}^4D_1$	(228)	Z_o (**1.31**) **1.31**; Z_c (**1.33**) **1.33**
3	4104.23	$^4P_2 - {}^4D_1$	(228)	Z_o (**0.87**) **2.62** 0.87
				Z_c (**0.87**) **2.60** 0.87
100	4062.69	$2^2P_2 - 4^2D_3$	(228)	
	Z_o (**0.00**) **1.06**			
	Z_c (**0.07**) (0.20) **1.00** 1.14 1.27 1.40			
100	4022.67	$2^2P_1 - 4^2D_2$	(228)	Z_o (0.00) **0.82**
				Z_c (**0.07**) 0.73 **0.87**
2	3648.39	$^2F_3 - {}^2G_4$	(228)	
	Z_o (0.00) 1.05			
	Z_c (**0.02**) (0.05) (0.08) **0.97** 0.94 0.91 0.87 0.84 0.81			
10	3621.25	$^4D'_2 - {}^4D'_2$	(228)	Z_o (0.00) 1.10; Z_c (0.00) 1.20
3	3614.22	$^4D'_3 - {}^4D'_3$	(228)	Z_o (0.00) 1.43; Z_c (0.00) 1.37
2	3609.30	$^2D_2 - {}^4P_1$	(228)	
	Z_o (**0.97**) **0.00**			
	Z_c (**0.93**) **0.13** 1.73			
10	3602.04	$^4D'_4 - {}^4D'_4$	(228)	Z_o (0.00) 1.48; Z_c (0.00) 1.43
2	3594.02	$^2D_3 - {}^4P_3$	(22)	
	Z_o 0.99			
	Z_c (0.20) (0.60) (**1.00**) 0.60 1.00 **1.40** 1.80 2.20			
10	3530.39	$^2D_2 - {}^4F_2$	(228)	
	Z_o (0.00) **1.14**			
	Z_c (**0.11**) (0.34) **1.37** 1.14 0.91 0.69			
6	3524.24	$^2F_3 - {}^4F'_4$	(228)	
	Z_o (0.00) 1.50			
	Z_c (**0.18**) (0.57) (0.95) **2.19** 1.81 1.43 1.05 0.67 0.29			
3	3457.86	$^2D_3 - {}^4P_2$	(22)	
	Z_o (0.25) (0.79) 0.33 0.84			
	Z_c (**0.27**) (0.80) **0.40** 0.93 1.47 2.00			
3	3440.52	$^2D_2 - {}^4F_2$	(22)	
	Z_o 0.60			
	Z_c (0.20) (**0.60**) 0.20 **0.60** 1.00			
10	3337.85	$^2D_3 - {}^4F_4$	(228)	
	Z_o (**0.00**) **1.28**			
	Z_c (**0.02**) (0.06) (0.10) **1.34** 1.30 1.26 1.22 1.18 1.14			

Cu_{29}.—(*Continued*)

Int.	λ	Terms	4	Type
		Cu *I.*—(*Continued*)		
3	3279.82	$^2D_2 - {}^2F_3$	(22)	
	Z_o 0.00 1.56 (?)			
	Z_c (**0.03**) (0.09) **0.94** 0.89 0.83 0.77 (?)			
1000*r*	3273.97	$1^2S_1 - 2^2P_1$	(228)	Z_o (0.66) 1.34; Z_c (0.67) 1.33
1000*r*	3247.55	$1^2S_1 - 2^2P_2$	(228)	$Z_o = Z_c$ = (**0.33**) 1.00 1.67
8	3243.16	$^4F_4 - {}^4F'_5$	(228)	
	Z_o (0.00) 1.30			
	Z_c (**0.05**) (0.14) (0.24) (0.33) **1.67** 1.57 1.48 1.29 1.19 1.10 1.00			
5	3235.71	$^4F_2 - {}^4F'_3$	(228)	
	Z_o 0.61			
	Z_c (**0.31**) (0.94) **1.97** 1.34 0.71 0.09			
4	3208.23	$^2D_2 - {}^4D_3$	(22)	
	Z_o (0.19) (0.57) 1.67			
	Z_c (0.28) (0.85) 0.51 1.08 1.66 2.23			
10	3194.10	$^2D_2 - {}^4D'_2$	(228)	
	Z_o (**0.44**) **1.05**			
	Z_c (0.20) (**0.60**) 1.40 **1.00** 0.60			
3	3156.62	$^2D_2 - {}^4D'_1$	(22)	Z_o (0.31) 1.10
				Z_c (0.40) 0.40 1.20
10	3142.43	$^4P_2 - {}^4S_2$	(228)	
	Z_o 0.40			
	Z_c (0.13) (**0.40**) 2.14 **1.87** 1.60			
20	3108.60	$^4P_3 - {}^2F'_4$	(228)	
	Z_o 0.51			
	Z_c (**0.23**) (0.69) (1.15) **0.01** 0.45 0.91 1.37			
6	3093.99	$^2D_3 - {}^4D'_4$	(22)	
	Z_o (0.00) 1.78			
	Z_c (**0.11**) (0.34) (0.57) 0.85 1.08 1.31 1.54 1.77 **2.00**			
4	3073.80	$^2D_3 - {}^2F_3$	(22)	
	Z_o (0.30) 1.10			
	Z_c (0.17) (0.51) (**0.86**) 1.71 1.37 **1.03** 0.69 0.34			
8	3073.80	$^2D_3 - {}^2F_3$	(228)	
	Z_o **0.64** **1.51**			
	Z_c (0.19) (0.51) (**0.86**) 1.71 1.37 **1.03** 0.69 0.34			
10	3063.42	$^2D_2 - {}^2P_2$	(228)	
	Z_o **0.52** 1.18			
	Z_c (0.27) (**0.80**) 1.60 **1.06** 0.53			
6	3036.10	$^2D_2 - {}^2D'_2$	(22)	Z_o (0.42) (?)
				Z_c (0.00) 1.333 (?)
10	3010.84	$^2D_3 - {}^4D'_3$	(228)	
	Z_o (0.00) **1.15**			
	Z_c (0.09) (0.26) (**0.43**) 1.63 1.46 **1.29** 1.12 0.94			
10	2997.36	$^2D_2 - {}^2D'_2$	(228)	
	Z_o (0.21) (0.60) **1.85**			
	Z_c (**0.20**) (0.60) **1.80** 1.40 1.00 0.60			
20	2961.18	$^2D_3 - {}^2F_4$	(228)	
	Z_o (0.00) **1.17**			
	Z_c (**0.03**) (0.09) (0.14) **1.00** 1.06 1.12 1.17 1.23 1.29			
8	2882.94	$^2D_3 - {}^2P_2$	(228)	
	Z_o (0.00) **1.16**			
	Z_c (**0.07**) (0.20) **1.00** 1.14 1.27 1.40			
20	2824.38	$^2D_3 - {}^2D'_2$	(228)	Z_o (0.00) 1.23; Z_c (0.00) 1.20
2	2768.89	$^2D_2 - 3^2P_1$	(228)	Z_o (0.00) 0.96
				Z_c (**0.07**) 0.73 **0.87**
50*R*	2618.38	$^2D_3 - 3^2P_2$	(228)	
	Z_o (0.00) 1.12			
	Z_c (**0.07**) (0.20) **1.00** 1.14 1.27 1.40			
5*R*	2492.14	$^2S_1 - {}^4P_2$	(228)	Z_o (**0.00**) **1.80**
				Z_c (**0.13**)**1.60** 1.87
4*R*	2441.62	$^2S_1 - {}^4P_1$	(22)	Z_o (0.00) 2.27; Z_c (0.33) 2.33
2	2369.88	$^2D_2 - 4^2F_3$	(228)	
	Z_o (0.00) **1.13**			
	Z_c (**0.03**) (0.09) **0.94** 0.89 0.83 0.77			
2*R*	2263.09	$^2D_2 - {}^2P'_1$	(228)	Z_o (**0.00**) 0.79
				Z_c (**0.07**) 0.73 **0.87**
	2230.07	$^2D_3 - {}^2F'_4$	(228)	
	Z_o (0.00) **1.05**			
	Z_c (**0.03**) (0.09) (0.14) **1.00** 1.06 1.12 1.17 1.23 1.29			
2*R*	2227.74	$^2D_2 - {}^2F'_4$	(228)	
	Z_o (0.00) 0.79			
	Z_c (**0.03**) (0.09) **0.94** 0.89 0.83 0.77			
2*R*	2215.65	$^2D_2 - {}^2D'_2$	(228)	Z_o (0.00) 0.96
				Z_c (0.00) 0.80
2*R*	2214.56	$^2D_3 - {}^2P_2$	(228)	
	Z_o (0.00) 1.18			
	Z_c (**0.07**) (0.20) **1.00** 1.14 1.27 1.40			
2*R*	2199.65	$^2D_3 - {}^2D_3$	(228)	Z_o (0.00) 1.17
				Z_c (0.00) 1.20

Mn_{25} (11); Int. and λ (11); *cf.* (112); Terms (11, 37); in column (4) are notes and symbols

Int.	λ	Terms	4	Type
		Mn *I*		
10*R*	4823.522	$^6P_5 - {}^8S_4$	r	[(1) (3) (5) (7) **9** 11 13 15 17 19 21 23]/9
	Z_o (**0.1108**) (0.3324) (0.5540) (0.7756) **0.9973** 1.219 1.441 1.662 1.884			
	Z_c (**0.111**) (0.333) (0.555) (0.778) **1.00** 1.22 1.44 1.66 1.89 2.11 2.33 2.55			
9*R*	4783.432	$^6P_4 - {}^8S_4$	*†	[(2) (6) (10) (**14**) 112 116 120 **124** 128 132 136]/63
	Z_o (**0.211**) 1.785 1.845 1.905 **1.966** 2.026 2.087 2.147			
	Z_c (0.033) (0.095) (0.158) (**0.222**) 1.778 1.840 1.904 **1.968** 2.031 2.094 2.158			
9*R*	4754.058	$^6P_3 - {}^8S_4$	r	[(1) (3) (5) **9** 11 13 15 17 19]/7
	Z_o (**0.143**) (0.429) (0.716) **1.278** 1.565 1.851 2.173			
	Z_c (**0.143**) (0.429) (0.715) **1.286** 1.572 1.857 2.143 2.429 2.175			
2	4312.546	$^4P_2 - {}^4D_2$	r	[(1) (3) 5 7 9 **11**]/5
	Z_o (**0.206**) (0.618) 1.385 1.797 2.209			
	Z_c (**0.2**) (0.6) 1.0 1.4 1.8 **2.2**			
3	4284.084	$^4P_2 - {}^4D_1$	r	[(**13**) 13 **39**]/15
	Z_o (0.861) 0.861 **2.575**; Z_c (0.867) 0.867 **2.601**			
9	4281.097	$^4P_3 - {}^4D_3$	r	[(4) (12) (**20**) 36 44 **52** 60 68]/35
	Z_o (0.1113) (0.3375) (**0.5637**) 1.030 1.256 1.482 1.709 1.935			
	Z_c (0.1143) (0.3429) (**0.5715**) 1.029 1.257 **1.486** 1.714 1.943			
9	4265.920	$^4P_2 - {}^4D_2$	r	[(4) (**12**) 14 **22** 30]/15
	Z_o (**0.794**) 0.926 **1.456** 1.986			
	Z_c (0.2667) (**0.800**) 0.933 **1.466** 2.00			
8	4257.653	$^4P_1 - {}^4D_1$	‡	[(**4**) **4**]/3
	Z_o (**1.332**) **1.332**; Z_c (**1.333**) **1.333**			
7	4239.723	$^4P_1 - {}^4D_2$	r	[**7** (**11**) 29]/15
	Z_o **0.4623** (**0.7356**) 1.895; Z_c **0.467** (**0.733**) 1.933			
10	4235.306	$^4P_2 - {}^4D_4$	r§	[(**3**) (9) (15) **35** 41 47 53 59 65]/35
	Z_o (**0.0865**) (0.2595) (0.4325) **0.995** 1.168 1.341 1.514			
	Z_c (**0.0857**) (0.257) (0.429) **1.00** 1.171 1.343 1.514 1.686 1.857			
8	4235.125	$^4P_2 - {}^4D_3$	r‖	[(**17**) (51) **93** 127 161 195]/105
	Z_o (**0.163**) (0.489) 0.890 1.216 1.542 1.868			
	Z_c (**0.162**) (0.486) **0.886** 1.210 1.533 1.856			
6	4083.639	$^6D_3 - {}^6D'_4$	¶	[(**77**) (231) (385) **3115** 3269 3423 3577 3731 3785]/2205
	Z_o (0) 1.488			
6	4082.947	$^6D_2 - {}^6D'_3$	$T_p r$	[(**11**) (33) **141** 163 185 207]/105
	Z_o (**1.1040**) (0.312) **1.330** 1.583 1.746 1.954			
	Z_c (**0.105**) (0.314) **1.343** 1.553 1.762 1.972			
6	4079.428	$^6D_1 - {}^6D'_2$	**	[(**11**) **17** 39]/15
	Z_o(**0.733**) **1.130** 2.578; Z_c (**0.733**) **1.133** 2.600			
6	4079.245	$^6D_4 - {}^6D'_5$	T_p	[(1) (3) (5) (7) **91** 93 95 97 99 101 103 105]/63
	Z_o (0) 1.490			
2	4070.280	$^6D_1 - {}^6D'_1$	$T s$	[(0) 10]/3; Z_o (0) 3.343; Z_c (0.00) 3.333
2	4068.029	$^6D_2 - {}^6D'_2$	$T s$	[(0) 28]/15; Z_o (0) 1.867; Z_c (0) 1.866
4	4063.553	$^6D_3 - {}^6D'_3$	$T s$	[(0) 58]/35; Z_o (0) 1.652; Z_c (0) 1.657
2	4058.936	$^6D_2 - {}^6D'_1$	r	[(**11**) **17** 39]/15
	Z_o (**0.728**) **1.135** 2.598; Z_c (**0.733**) 1.133 2.600			
8	4055.553	$^6D_4 - {}^6D'_4$	$T s$	[(0) 100]/63; Z_o (0) 1.580; Z_c (0) 1.587
4	4048.760	$^6D_3 - {}^6D'_2$	r	[(**11**) (33) **141** 163 185 207]/105
	Z_o (**0.1025**) (0.3075) **1.345** 1.550 1.775 1.960			
	Z_c (**0.105**) (0.314) **1.343** 1.553 1.762 1.972			
10	4041.366	$^6D_5 - {}^6D'_5$	$T s$	[(0) 14]/9; Z_o (0) 1.554; Z_c (0) 1.555
5	4035.730	$^6D_4 - {}^6D'_3$	T_p	[(**77**) (231) (385) **3115** 3269 3423 3577 3731 3785]/2205
	Z_o (0) 1.501			
9*R*	4034.489	$^8S_3 - {}^6P_3$	r	[(1) (3) **7** 9 11 13]/5
	Z_o (**0.1997**) (0.5991) **1.412** 1.811 2.210 2.609			
	Z_c (**0.2**) (0.6) **1.4** 1.8 2.2 2.6			
9*R*	4033.074	$^8S_3 - {}^6P_2$	††	[(2) (6) (**10**) 60 64 **68** 72 76]/35
	Z_o (**0.251**) 1.700 1.830 **1.945** 2.070 2.190			
	Z_c (0.0571) (0.1714) (**0.2860**) 1.714 1.829 **1.943** 2.057 2.172			

Mn_{25}.—(*Continued*)

Int.	λ	Terms	4	Type
		Mn *I*.—(*Continued*)		
10*R*	4030.760	$^8S_3 - {}^6P_4$	r	[(1)(3)(5) **7** 9 11 13 15 17]/7
	Z_o (**0.142**) (0.426) (0.710) **0.994** 1.278 1.562 1.846 2.130 2.414			
	Z_c (**0.143**) (0.429) (0.715) **1.000** 1.287 1.573 1.862 2.145 2.434			
8	4018.108	$^6D_5 - {}^6D'_4$	T_p	[(1) (3) (5) (7) **91** 93 95 97 99 101 103 105]/63
	Z_o (0) 1.505			
	3843.985	$^6D_1 - {}^6F_2$	r	[**1** (**17**) 33]/15
	Z_o **0.076** (**1.135**) 2.199; Z_c **0.067** (**1.133**) 2.20			
	3841.081	$^6D_2 - {}^6F_2$	r	[(**29**) **51** (87) 109 167 225]/105
	Z_o (**0.2794**) **0.4831** (0.8316) 1.037 1.592 2.146			
	Z_c (**0.2762**) **0.4857**) (0.8286) 1.038 1.590 2.143			
	3839.777	$^6D_1 - {}^6F_1$	‡‡	[**4** (**6**)]/3; Z_o **1.337** (**1.987**); Z_c **1.333** (**2.000**)
8	3834.363	$^6D_3 - {}^6F_4$	**	[(**287**) (861) (1435) **1645** 2219 2793 3367 3941 4515]/2205
	Z_o (**0.1297**) (0.3891) (0.6485) **0.7393** 0.9988 1.258 1.518			
	Z_c (**0.1302**) (0.3905) (0.6508) **0.7460** 1.006 1.276 1.527 1.787 2.047			
6	3833.864	$^6D_2 - {}^6F_2$	§§	[(6) **10** (**18**) **22** 34]/15
	Z_o (0.398) 0.648 (**1.194**) **1.444** 2.240			
	Z_c (0.40) 0.666 (**1.20**) **1.466** 2.266			
2	3829.674	$^6D_3 - {}^6F_1$	w	[9 (**19**) **47**]/15
	Z_o 0.605 (**1.262**) **3.128**; Z_c 0.600 (**1.266**) **3.133**			
5	3823.896	$^6D_3 - {}^6F_3$	r	[(6) (18) (**30**) 28 40 **52** 64 76]/35
	Z_o (0.173) (0.520) (**0.866**) 0.787 1.133 **1.479** 1.825 2.171			
	Z_c (0.71) (0.513) (**0.857**) 0.798 1.142 **1.486** 1.830 2.174			
9	3823.515	$^6D_4 - {}^6F_5$	r	[(**53**) (159) (265) (371) **623** 729 835 941 1047 1153 1259 1365]/693
	Z_o (**0.0764**) (0.229) (0.382) (0.535) **0.901** 1.053 1.206 1.359 1.512 1.665			
	Z_c (**0.0765**) (0.229) (0.382) (0.535) **0.899** 1.052 1.205 1.358 1.511 1.664 1.817 1.970			
6	3809.599	$^6D_4 - {}^6F_4$	r	[(6) (18) (30) (**42**) 58 70 82 **94** 106 118 130]/63
	Z_o (0.1124) (0.2990) (0.4856) (**0.6722**) 0.940 1.128 1.314 **1.501** 1.688 1.874 2.061			
	Z_c (0.095) (0.286) (0.476) (**0.666**) 0.921 1.111 1.302 **1.492** 1.682 1.873 2.063			
10	3806.866	$^6D_5 - {}^6F_6$	T_p‖‖	
3	3790.215	$^6D_5 - {}^6F_5$	Q_p	[(6) (18) (30) (42) (**54**) 100 112 124 136 **148** 160 172 184 196]/99
	Z_o . . . (**0.586**) . . . **1.460** . . . ; Z_c . . . (**0.545**) . . . **1.494** . . .			
3	3629.739	$^6P_4 - {}^6D_3$	$T s-$	[(1) (3) (5) 55 57 59 61 63 **65**]/63
	Z_o (0) 1.769			
	Z_c (**0.029** 0.086 0.143) 1.57 1.63 1.69 1.74 1.80 **1.86**			
4	3623.790	$^6P_3 - {}^6D_2$	$T s-$	[(1) (3) 195 197 199 **201**]/105
	Z_o (0) 1.885			
	Z_c (**0.0095**) (0.0286) 1.857 1.876 1.895 **1.914**			
4	3619.399	$^6P_2 - {}^6D_1$	r	[(**7**) 29 43]/15
	Z_o (**0.459**) **1.931** 2.869; Z_c (**0.466**) **1.933** 2.866			
6	3610.296	$^6P_2 - {}^6D_2$	r	[(4) (**12**) 24 **32** 40]/15
	Z_o (0.268) (0.805) 1.621 **2.152** 2.684			
	Z_c (0.266) (**0.800**) 1.800 **2.133** 2.666			
6	3608.484	$^6P_3 - {}^6D_3$	r	[(4) (12) (**20**) 46 54 **62** 70 78]/35
	Z_o (0.115) (0.345) (**0.571**) 1.319 1.549 **1.779** 2.009 2.240			
	Z_c (0.114) (0.343) (**0.572**) 1.314 1.543 **1.771** 2.000 2.230			
6	3607.530	$^6P_4 - {}^6D_4$	¶¶	[(4) (12) (20) (**28**) 80 88 96 **104** 112 120 128]/63
	Z_o (**0.421**) 1.308 1.429 1.550 **1.671** 1.792 1.913 2.034			
	Z_c (0.064) (0.191) (0.317) (**0.444**) 1.270 1.397 1.523 **1.651** 1.778 1.904 2.031			
3	3595.112	$^6P_2 - {}^6D_3$	r	[(**13**) **19** (39) 45 71 97]/35
	Z_o (**0.3661**) **0.538** (1.105) 1.276 2.015 2.754			
	Z_c (**0.371**) 0.543 (1.113) 1.285 2.027 2.769			
5	3586.540	$^6P_3 - {}^6D_4$	r	[(**329**) (987) (1645) **1855** 2513 3171 3828 4485 5145]/2205
	Z_o (**0.145**) (0.435) (0.725) **0.8495** 1.139 1.429 1.719 2.009 2.299			
	Z_c (**0.149**) (0.447) (0.745) **0.842** 1.139 1.438 1.736 2.035 2.333			
6	3577.880	$^6P_4 - {}^6D_5$	r	[(**5**) (15) (25) (35) **63** 73 83 93 103 113 123 133]/63
	Z_o (**0.0768**) (0.2304) (0.3840) (0.5376) **0.9977** 1.151 1.304 1.458 1.620 1.770			
	Z_c (**0.0793**) (0.238) (0.397) (0.555) **1.000** 1.159 1.317 1.476 1.635 1.794			

Mn_{25}.—(*Continued*)

Int.	λ	Terms	4	Type
		Mn *I*.—(*Continued*)		
9*R*	2801.076	$^6S_2 - {}^6P_2$		[(**1**) (3) **7 9 11 13**]/5
	Z_o (**0.199**) (0.597) **1.395** 1.793 2.191 2.589			
	Z_c (**0.2**) (0.6) **1.4** 1.8 2.2 2.6			
		Mn *II*		
6	3497.540	$^5P_2 - {}^5D_1$	*r*	[(**0**) (2) 9 11 **13**]/6
	Z_o (**0**) (0.332) 1.493 1.825 **2.157**			
	Z_c (**0.0**) (0.333) 1.5 1.833 **2.166**			
8	3495.840	$^5P_1 - {}^5D_0$	*T*	[(0) 5]/2; Z_o (0) 2.498; Z_c (0.0) 2.5
8	3488.618	$^5P_1 - {}^5D_1$	*r*	[(**2**) **3 5**]/2
	Z_o (**0.9987**) **1.499 2.498**; Z_c (**1.0**) **1.5 2.5**			
7	3482.918	$^5P_2 - {}^5D_2$	*r*	[(2) (**4**) **7 9 11** 13]/6
	Z_o (0.3312) (**0.6624**) 1.165 **1.496 1.827** 2.158			
	Z_c (0.333) (**0.666**) 1.166 **1.50 1.833** 2.167			
8	3460.332	$^5P_2 - {}^5D_3$	*r*	[(**0**) (2) (4) **5** 7 9 11 13]/6
	Z_o (**0.0**) (0.329) (0.658) **0.8294** 1.159 1.488 1.817			
	Z_c (**0.0**) (0.333) (0.666) **0.833** 1.166 1.50 1.833 2.167			
9	3441.999	$^5P_3 - {}^5D_4$	***	[(**0**) (1) (2) (3) **6 7 8 9** 10 11 12]/6
	Z_o (0.0) (0.1655) (0.331) (0.4965) **0.9992** 1.165 1.330 1.496			
	Z_c (**0.0**) (0.166) (0.332) (0.498) **1.00** 1.166 1.333 1.50 1.66 1.83 2.00			
10	2949.207	$^5S_2 - {}^5P_3$	*r*	[(**0**) (1) (2) **3** 4 5 6 7]/3
	Z_o (**0**) (0.336) (0.672) **0.995** 1.331 1.667 2.003			
	Z_c (**0.0**) (0.333) (0.667) **1.00** 1.333 1.667 2.00 2.333			
9	2939.315	$^5S_2 - {}^5P_2$	†††	[(1) (**2**) 10 **11 12** 13]/6
	Z_o (**0.331**) **1.837 2.01**			
	Z_c (0.167) (**0.334**) 1.667 **1.833 2.00** 2.167			
8	2933.066	$^5S_2 - {}^5P_1$	*r*	[(**0**) (1) **3** 4 5]/2
	Z_o (**0**) (0.501) **1.490** 1.991 2.492			
	Z_c (**0.0**) (0.5) **1.5** 2.0 2.5			
9	2605.695	$^7S_3 - {}^7P_2$	*rd*	[(**0**) (1) (2) **4** 5 6 7 8]/3
	Z_o (**0.0**) (0.347) (0.694) **1.275** 1.622 1.969 2.316			
	Z_c (**0.0**) (0.333) (0.666) **1.333** 1.667 2.00 2.33 2.67			
9	2593.734	$^7S_3 - {}^7P_3$	‡‡‡	[(2) (4) (**6**) 17 19 **21 23** 25 27]/12
	Z_o (**0.495**) **1.760 1.920**			
	Z_c (0.167) (0.334) (**0.500**) 1.417 1.584 **1.750 1.916** 2.083 2.250			
10	2576.116	$^7S_3 - {}^7P_4$	*r*	[(**0**) (1) (2) (3) **4** 5 6 7 8 9 10]/4
	Z_o (**0**) (0.248) (0.496) (0.744) **0.992** 1.240 1.488 1.736			
	Z_c (**0.0**) (0.25) (0.5) (0.75) **1.0** 1.25 1.50 1.75 2.0 2.25 2.5			

* Very asymmetric; disturbed by preceding line.
† Resolution is complete for σ, but not for π.
‡ The π- and σ-components coincide.
§ Disturbed by following line. ‖ Disturbed by preceding line.
¶ All components very broad. ** Partial coincidence with following line.
†† Very asymmetric; π-components not completely resolved.
‡‡ Possibly disturbed. §§ Partial coincidence with preceding line.
‖‖ Qualitatively correct, but not measurable.
¶¶ Only the σ-components on short-λ side are completely resolved.
*** π-components completely resolved; σ-components are disturbed and only partially resolved.
††† Not completely resolved. ‡‡‡ Disturbed; not completely resolved.

Mo_{42} (245); Int. (96); λ (245); *cf.* (112); spectral structure (39, 111, 148, 245)

Int.	λ	Terms	4	Type
		Mo *I*		
	6030.65	$^5P_3 - {}^5D_4$	*	[(**0**) (1) (2) (3) **6 7 8 9** 10 11 12]/6
	Z_o **1.0**			
	Z_c (0) (0.167) (0.333) (0.500) **1.000** 1.167 1.333 1.500 1.667 1.833 2.000			
4	5791.88	$^5P_1 - {}^5D_2$		[(**0**) **1** (2) 3 5]/2
	Z_o (0) **0.503** 1.006 1.509 2.515			
	Z_c (0) 0.500 1.000 1.500 2.500			
4	5751.42	$^5P_2 - {}^5D_2$		[(2) (4) **7 9 11** 13]/6
	Z_o (0.332) (**0.664**) 1.163 **1.494 1.826** 2.159			
	Z_c (0.333) (**0.667**) 1.167 **1.500 1.833** 2.167			
3	5722.78	$^5P_3 - {}^5D_3$	*w*	[(**0**) (1) (2) 8 9 10 11 **12**]/6
	Z_o (**0**) (0.17) (0.34) **2.00**			
	Z_c (**0**) (0.167) (0.333) 1.333 1.500 1.667 1.833 **2.000**			
4	5689.22	$^5P_1 - {}^5D_1$		[(2) 3 5]/2
	Z_o (0.990) 1.485 2.475; Z_c (1.000) 1.500 2.500			
4	5650.15	$^5P_2 - {}^5D_1$		[(0) (2) **9** 11 13]/6
	Z_o (**0**) (0.334) **1.505** 1.838 2.173			
	Z_c (**0**) (0.333) **1.500** 1.833 2.167			
4	5632.48	$^5P_1 - {}^5D_0$		[(0) 5]/2; Z_o (0) 2.51; Z_c (0) 2.50
6	5570.57	$^5S_2 - {}^5P_1$		[(**0**) (1) 3 4 5]/2
	$Z_o = Z_c =$ (**0**) (0.500) **1.500** 2.000 2.500			

Mo_{42}.—(*Continued*)

Int.	λ	Terms	4	Type
		Mo *I*.—(*Continued*)		
6	5533.06	$^5S_2 - {}^5P_2$		[(1) (**2**) 10 **11 12** 13]/6
	Z_o (0.168) (**0.334**) 1.670 **1.838 2.006** 2.173			
	Z_c (0.167) (**0.333**) 1.667 **1.833 2.000** 2.167			
6	5506.54	$^5S_2 - {}^5P_3$		[(0) (1) (2) **3** 4 5 6 7]/3
	$Z_o = Z_c =$ (**0**) (0.333) (0.667) **1.000** 1.333 1.667 2.000 2.333			
3	4662.94	$^5P_2' - {}^5D_3$	†	[(**0**) (2) (4) **5** 7 9 11 13]/6
	Z_o (**0**) (0.324) (0.650) **0.809** 1.136 1.455 1.780 2.111			
	Z_c (**0**) (0.333) (0.667) **0.833** 1.167 1.500 1.833 2.167			
3	4626.65	$^5P_3' - {}^5D_4$	‡	[(**0**) (1) (2) (3) **6 7 8 9** 10 11 12]/6
	Z_o (**0**) (0.163) (0.327) (0.488) **0.975**			
	Z_c (0) (0.167) (0.333) (0.500) **1.000** 1.167 1.333 1.500 1.667 1.883 2.000			
3	4595.32	$^5P_1' - {}^5D_1$		[(2) 3 5]/2
	$Z_o = Z_c =$ (1.00) 1.50 2.50			
3	4576.67	$^5P_2' - {}^5D_2$		[(2) (**4**) **7 9 11** 13]/6
	$Z_o = Z_c =$ (0.333) (**0.667**) 1.167 **1.500 1.833** 2.167			
2	4558.29	$^5P_1' - {}^5D_0$		[(0) 5]/2; $Z_o = Z_c =$ (0) 2.500
3	4524.50	$^5P_3' - {}^5D_3$		[(1) (2) (**3**) 7 8 **9 10** 11 12]/6
	Z_o (0.166) (0.332) (**0.498**) 1.163 1.327 **1.493 1.660** 1.824 1.990			
	Z_c (0.167) (0.334) (**0.500**) 1.167 1.333 **1.500 1.667** 1.833 2.000			
2	4485.15	Z_o (0) (0.478) (0.957) (1.435) 0 0.478 0.957 1.435 1.914 2.392		
1	4472.20	Z_o (0) 0.996		
1	4391.70	Z_o (0) (2.06) 1.03 3.09 5.15		
4	4381.85	Z_o§ (0.372) (0.651) (0.929) (1.207) 1.485 1.763 2.041 2.319		
2	4380.49	$^5D_4 - {}^5F_4$		[(3) (6) (9) (**12**) 18 21 24 **27 30** 33 36 39]/20
	Z_o **0.6** **1.4**			
	Z_c (0.15) (0.30) (0.45) (**0.60**) 0.90 1.05 1.20 **1.35 1.50** 1.65 1.80 1.95			
2	4369.25	$^5D_3 - {}^5F_3$		[(1) (2) (**3**) 3 4 **5 6** 7 8]/4
	Z_o (0.243) (0.485) (**0.730**) 0.730 0.970 **1.214 1.455** 1.700 1.940			
	Z_c (0.250) (0.500) (**0.750**) 0.750 1.000 **1.250 1.500** 1.750 2.000			
3	4350.52	$^5D_2 - {}^5F_2$		[(1) (**2**) (3) **1 2** 3 4]/2
	Z_o (0.500) (**0.999**) 0.500 **0.999 1.499** 1.998			
	Z_c (0.500) (**1.000**) 0.500 **1.000 1.500** 2.000			
3	4341.58	Z_o (0) 0.797		
	4326.90	$^5D_1 - {}^5F_1$		[(3) 0 3]/2
	Z_o (1.503) 0 1.503; Z_c (1.500) 0 1.503			
3	4326.29	Z_o (0) (0.343) (0.686) 0 0.343 0.686 1.029 1.372		
1	4296.34	Z_o (0) 1.051		
3	4294.03	$^5D_0 - {}^5F_1$		[(0) 0]; $Z_o = Z_c =$ (0) 0
3	4293.42	$^5D_3 - {}^5F_3$		[(**0**) (1) (2) **3** 4 5 6 7]/4
	Z_o (**0**) (0.252) (0.504) **0.756** 1.008 1.260 1.512 1.764			
	Z_c (**0**) (0.250) (0.500) **0.750** 1.000 1.250 1.500 1.750			
3	4292.37	$^5D_1 - {}^5F_2$		[(**0**) (1) 1 **2** 3]/2
	$Z_o = Z_c =$ (**0**) (0.500) **0.500** 1.000 1.500			
2	4291.40	Z_o (0) 1.171		
2	4289.58	Z_o (0) 1.065		
3	4288.82	$^5D_3 - {}^5F_4$	‖	[(**0**) (3) (6) (9) **18** 21 24 27 30 33 36]/20
	Z_o (**0**) **0.9**			
	Z_c (**0**) (0.15) (0.30) (0.45) **0.90** 1.05 1.20 1.35 1.50 1.65 1.80			
3	4277.49	$^5D_4 - {}^5F_5$		[(0) (1) (2) (3) (4) **10** 11 **12** 13 14 15 16 17 18]/10
	Z_o **1.0**			
	Z_c (**0**) (0.1) (0.2) (0.3) (0.4) **1.0** 1.1 1.2 1.3 1.4 1.5 1.6 1.7 1.8			
2	4269.47	Z_o (0) 1.200		
	4255.10	Z_o (0) 1.133		
3	4232.82	Z_o (0) 1.09	¶	
3	4120.29	Z_o (0) 1.176	¶	
2	4105.24	Z_o 0 1.02		
10	3903.11	$^7S_3 - {}^7P_3$		[(**0**) (1) (2) **4** 5 6 7 8]/3
	$Z_o = Z_c =$ (**0**) (0.333) (0.667) **1.333** 1.667 2.000 2.333 2.667			
2	3901.93	$^5D_4 - {}^5D_3'$		[(0) 3]/2; Z_o (0) 1.498
2	3886.98	$^5D_3 - {}^5D_2'$		[(0) 3]/2; Z_o (0) 1.507
2	3869.23	$^5D_2 - {}^5D_1'$		[(0) 3]/2; Z_o (0) 1.500
10	3864.30	$^7S_3 - {}^7P_3$	**	[(1) (2) (**3**) 21 22 **23 24** 25 26]/12
	3851.54	$^5D_1 - {}^5D_0$	††	[(0) 3]/2; Z_o (0) 1.460
3	3833.88	$^5D_4 - {}^5D_4'$		[(0) 3]/2; Z_o (0) 1.497
3	3829.02	$^5D_3 - {}^5D_3'$		[(0) 3]/2; Z_o (0) 1.498
2	3826.85	$^5D_2 - {}^5D_2'$		[(0 3]/2; Z_o (0) 1.499
1	3825.50	Z_o (0) 0.756		
2	3823.13	$^5D_1 - {}^5D_1'$		[(0) 3]/2; Z_o (0) 1.515
10	3798.41	$^7S_3 - {}^7P_4$		[(**0**) (1) (2 3) **4** 5 6 7 8 9 10]/4
	Z_o (0) (0.248) (0.495) (0.743) **0.990** 1.238 1.485 1.733 1.980 2.203 2.475			
	Z_c (0) (0.250) (0.500) (0.750) **1.000** 1.250 1.500 1.750 2.000 2.250 2.500			

Mo$_{42}$.—(*Continued*)

Int.	λ	Terms	4	Type
		Mo *I*.—(*Continued*)		
2	3797.42	$^5D_0 - {}^5D_1'$		[(0) 3]/2; Z_o (0) 1.498
2	3781.78	$^5D_2 - {}^5D_1'$		[(0) 3]/2; Z_o (0) 1.464
2	3770.60	$^5D_2 - {}^5D_2$		[(0) 3]/2; Z_o (0) 1.501
2	3763.50	$^5D_3 - {}^5D_4$		[(0) 3]/2; Z_o (0) 1.490
1	3728.41	Z_o (0) 1.222		
1	3717.04	Z_o (0) 1.060		
3	3695.14	Z_o (0) (0.266) (0.532) 0.055 0.321 0.587 0.853 1.119		
3	3680.81	Z_o (0.963) 1.360 1.568 1.775 1.985 2.194		
2	3677.64	Z_o (0) 1.570		
2	3640.78	Z_o (0) 1.161		
2	3626.36	Z_o (0) 1.500		
2	3612.61	Z_o (0) 1.216		
1	3571.41	Z_o (0) 1.134		
2	3475.19	Z_o (1.116) 1.116 2.232		
	3447.29	$^5D_4 - {}^5F_5$		[(**0**) (1) (2) (3) (4) **10** 11 12 13 14 15 16 17 18]/10
	Z_o	**0.9**		
	Z_c (**0**) (0.1) (0.2) (0.3) (0.4) **1.0** 1.1 1.2 1.3 1.4 1.5 1.6 1.7 1.8			
	3443.42	Z_o (0) 1.500		
	3438.97	Z_o (0) 0.776		
	3422.47	Z_o (0) 1.512		
	3404.50	$^5D_3 - {}^5F_3$		[(1) (2) (**3**) 3 4 **5 6** 7 8]/4
	Z_o (0.263) (0.526) (**0.789**) 0.789 1.060 **1.322 1.590**			
	Z_c (0.250) (0.500) (**0.750**) 0.750 1.000 **1.250 1.500** 1.750 2.000			
	3384.80	$^5D_3 - {}^5F_4$		[(**0**) (3) (6) (9) **18** 21 24 27 30 33 36]/20
	Z_o	**0.8**		
	3382.66	Z_o(0) 1.468		
	3363.98	$^7D_2 - {}^7F_3$		[(0) (1) (2) 1 2 3 4 5]/2
	Z_o (0) (0.502) (1.005) 0.502 1.005 1.507 2.010 2.501			
	Z_c (0) (0.500) (1.000) 0.500 1.000 1.500 2.000 2.500			
	3358.26	$^5D_2 - {}^5F_3$	‡‡	[(**0**) (1) (2) **3** 4 5 6 7]/4
	Z_o (**0**) (0.243) (0.487) **0.725** 0.965 1.215 1.458 1.700			
	Z_c (**0**) (0.250) (0.500) **0.750** 1.000 1.250 1.500 1.750			
	3347.17	$^5D_0 - {}^5F_1$		$Z_o = Z_c$ (0) 0
	3344.90	$^5D_1 - {}^5F_2$		[(**0**) (1) **1 2** 3]/2
	Z_o (**0**) (0.503) **0.503** 1.006 1.509			
	Z_c (**0**) (0.500) **0.500** 1.000 1.500			
	3194.11	$^7S_3 - {}^7P_2'$		[(**0**) (1) (2) **4** 5 6 7 8]/3
	Z_o (**0**) (0.327) (0.647) **1.302** 1.615 1.940 2.271 2.591			
	Z_c (**0**) (0.333) (0.667) **1.333** 1.667 2.000 2.333 2.667			
	3132.70	$^7S_3 - {}^7P_4'$		[(**0**) (1) (2) (3) **4** 5 6 7 8 9 10]/4
	Z_o (**0**) (0.252) (0.505) (0.758) **1.010** 1.263 1.515 1.768 2.020 2.247 2.525			
	Z_c (**0**) (0.250) (0.500) (0.750) 1.000 1.250 1.500 1.750 2.000 2.250 2.500			
		Mo *II*		
8§§	4433.70	$^4P_1 - {}^4D_2$		[(11) 7 29]/15
	Z_o (0.730) **0.464** 1.929; Z_c (0.733) **0.466** 1.933			
10	4377.92	$^4P_1 - {}^4D_1$		[(4) 4]/3
	Z_o (2.672) 2.672; Z_c (2.666) 2.666			
	4363.10	Z_o (0.283) (0.749) 0.433 0.999 1.565 2.131		
2	4328.19	Z_o (0.135) (0.406) 0.677 0.948 1.219 1.390		
10	4279.20	$^4P_2 - {}^4D_2$		[(4) (**12**) 14 **22** 30]/15
	Z_o (0.270) (0.806) 0.942 1.480 2.022			
	Z_o (0.267) (0.799) 0.933 1.465 2.000			
10	4250.85	Z_o (0.171) (0.514) (0.856) 0.514 0.856 1.199 1.541 1.883		
2	4227.23	$^4P_2 - {}^4D_1$		[(13) **13 39**]/15
	Z_o (0.885) 0.885 **2.655**; Z_c (0.866) 0.866 2.600			
2	4147.02	Z_o (0.20) 0.93 1.33		
2	4125.80	Z_o (0) 1.159		
6	4122.52	Z_o (0) 0.716	T_pB	
5	4119.78	Z_o (0.169) (0.506) (0.843) 0.506 0.843 1.180		
15	3961.61	Z_o (0.099) (0.297) (0.495) 0.829		
6	3786.52	Z_o (0.495) 1.155		
5	3755.63	Z_o (0.108) (0.323) (0.538) 0.753 0.968 **1.183** 1.398 1.613		
3	3744.55	Z_o (0) 0.986		
6	3742.49	$^4D_2 - {}^4F_2$		[(2) (6) 0 **4** 8]/5
	Z_o (0.396) **1.888** 0 **0.792** 1.584			
	Z_c (0.400) **1.200** 0 **0.800** 1.600			
8	3702.72	$^4D_1 - {}^4F_2$		[(1) 1 **3**]/5
	Z_o (0.204) 0.204 0.612; Z_c (0.200) 0.200 0.600			
10	3692.82	$2f_o$ = 1.58	T_pB	
15	3688.49	Z_o (0) 1.263	T_p	
3	3670.87	Z_o (0.150) 0.150 0.300		
4	3658.41	Z_o 1.227		
4	3652.61	Z_o (0) 1.171		
8	3651.30	Z_o‖‖ (0.108) (0.325) (0.541) . . . **1.793**		

Mo$_{42}$.—(*Continued*)

Int.	λ	Terms	4	Type
		Mo *II*.—(*Continued*)		
3	3591.84	Z_o (0) 0.618		
2	3528.04	Z_o (0) 1.096		
2	3346.35	Z_o (0) 1.462		
2	3287.35	Z_o (0.696) 2.087		
3	3254.83	Z_o (1.33) 1.133		
3	2965.40	$^6D_4 - {}^6F_5$		[(**43**) (129) (215) 285 371 457 543 629 **715**]/315
	Z_o (**0.136**) (0.410) (0.683) . . . **2.270**			
	Z_c (**0.136**) (0.410) (0.683) 0.905 1.178 1.451 1.724 1.997 **2.270**			
4	2963.92	$^6D_3 - {}^6F_2$		[(**31**) (93) 81 143 205 **267**]/105
	Z_o (**0.296**) (0.890) 0.775 1.368 1.962 **2.551**			
	Z_c (**0.295**) (0.886) 0.771 1.362 1.954 **2.543**			
5	2934.41	$^6D_1 - {}^6F_1$		[(6) 4]/3; $Z_o = Z_c$ (2.000) 1.333
4	2930.60	$^6D_2 - {}^6F_2$		[(6) (**18**) 10 **22** 34]/15
	Z_o (0.398) (**1.196**) 0.664 **1.461** 2.258			
	Z_c (0.400) (**1.200**) 0.667 **1.468** 2.267			
12	2923.50	$^6D_3 - {}^6F_3$	¶¶	[(6) (18) (**30**) 28 40 **52** 64 76]/35
	Z_o (. . .) 0.803 1.147 **1.490** 1.835 2.179			
	Z_c (. . .) 0.800 1.143 **1.486** 1.828 2.171			
10	2912.02	$^6D_4 - {}^6F_4$		[(6) (18) (30) (**42**) 58 70 82 **94** 106 118 130]/63
	$2B_o$ = 4.17, $2B_c$ = 4.127			
8	2909.20	$^6D_1 - {}^6F_2$		[(17) −1 33]/15
	Z_o (1.133) 0.000 2.200; Z_c (1.133) −0.066 2.200			
	2896.22	$^6D_5 - {}^6F_5$		[(5) (15) (25) (35) (45) **99** 109 119 129 139]/99
	$2f_o$ = 1.96, $2f_c$ = 2.00			
5	2894.52	$^6D_5 - {}^6F_5$		[(6) (18) (30) (42) (**54**) 100 112 124 135 **148** 160− −]/99
	$2B_o$ = 3.96, $2B_c$ = 4.2			
4	2891.10	$^6D_2 - {}^6F_3$		[(**29**) (87) **51** 109 167 225]/105
	Z_o (**0.275**) (0.825) **0.483** 1.033 1.583 2.132			
	Z_c (**0.276**) (0.829) **0.486** 1.038 1.590 2.143			
10	2871.61	$^6D_3 - {}^6F_4$		[(**41**) (123) (185) **235** 317 399 481 563 645]/315
	$2f_o$ = 1.54, $2f_c$ = 1.49			
12	2848.30	$^6D_4 - {}^6F_5$		[(**53**) (159) (265) (371) **623** 729 835 941−]/693
	$2f_o$ = 1.70, $2f_c$ = 1.798			
3	2729.71	$^6P_2 - {}^6D_3$		[(**13**) (39) **19** 45 71 97]/35
	Z_o (**0.369**) 1.108 **0.539** 1.277 2.014 2.751			
	Z_c (**0.371**) 1.115 **0.543** 1.286 2.028 2.771			
10	2701.49	$^6P_2 - {}^6D_2$		[(4) (**12**) 24 **32** 40]/15
	Z_o (0.267) (**0.799**) 1.698 **2.131** 2.664			
	Z_c (0.267) (**0.800**) 1.600 **2.133** 2.667			
8	2683.30	$^6P_2 - {}^6D_1$		[(7) **29** 43]/15
	Z_o (0.468) **1.938** 2.873; Z_c (0.467) **1.933** 2.867			
10	2660.69	$^6D_5 - {}^6D_4'$		[(1) (3) (5) (7) **91** 93 95 97 99 101 103 105]/63
	$2f_o$ = 2.85, $2f_c$ = 2.88			
7	2653.47	$^6D_4 - {}^6D_3'$		[(**11**) (33) (55) **445** 489 511 533 555]/315
	$2f_o$ = 2.86, $2f_c$ = 2.825			
8	2646.57	$^6D_3 - {}^6D_2'$		[(**11**) 33 **141** 163 185 207]/105
	$2f_o$ = 2.72, $2f_c$ = 2.68			
7	2636.74	$^6D_2 - {}^6D_1'$		[(11) **17** 39]/15
	Z_o (0.734) **1.135** 2.604; Z_c (0.733) **1.133** 2.600			
3	2619.40	$^6D_1 - {}^6D_1'$		[(0) 10]/3; $Z_o = Z_c$ = (0) (0.333)
5	2602.92	$^6D_1 - {}^6D_2'$		[(11) **17** 39]/15
	Z_o 0.737 **1.139** 2.612; Z_c 0.733 **1.133** 2.600			
4	2593.82	$^6D_2 - {}^6D_3'$		[(**11**) 33 **141** 163 185 207]/105
	$2f_o$ = 2.64, $2f_c$ = 2.68			
6	2586.01	$^6D_4 - {}^6D_5$		[(**1**) (3) (5) (7) **91** 93 95 97 99 101 103]/63
	$2f_o$ = 2.6, $2f_c$ = 2.88			

* Number (21) of components is correct, but components are not measurable.
† Measured components on one side, others obscured by λ = 4662.11.
‡ Resolution of σ-components is visible, but not measurable.
§ All π-components of same intensity. Type is extraordinarily asymmetric.
‖ Components resolved, but not measurable.
¶ Pseudo-type with narrow components.
** Not resolved, but type is qualitatively correct. †† Obscured.
‡‡ Asymmetrically distorted; not completely resolved. §§ From (64).
‖‖ The inner σ-components are too weak.
¶¶ Only the σ-components are resolved.

Ne_{10} (14); Int. and λ (181, 182); Terms (101); letters in column (4) indicate the ground type: type *a*: $j_z > j_y$, $g_x < g_y$, ± [(0) 1 3 4 5]/2; type *b*: $j_z > j_y$, $g_x > g_y$, ± [(0) 1 3 4 5]/2; type *c*: $j_x = j_y$, $g_x \neq g_y$, ± [1 2 3 4 5 6]/2; type *d*: j_x or $j_y = 0$, $g_x = g_y$, ± [(0) 4]/2.

Int.	λ	Terms	4	Type
		Ne *I*		
10	7245.165	$^3P_1 - {}^3S_1$	*c*	[(8) 22 30]/15
	Z_o (0.515) 1.454 1.979; Z_c (0.533) 1.467 2.000			
10	7032.410	$^3P_2 - {}^3S_1$	*a*	[(0) (1) 2 3 4]/2
	Z_o (0) (0.488) **1.013** 1.5006 1.988			
	Z_c (0) (0.500) 1.000 1.500 2.000			
10	6929.465	$^1P_1 - {}^3P_2$	*b*	[(0) (6) 31 37 43]/30
	Z_o (0) (0.1933) 1.026 1.224 **1.423**			
	Z_c (0) (0.200) 1.033 1.233 1.433			
2	6717.042	$^1P_1 - {}^3D_1$	*c*	[(1) 30 31]/30
	Z_o (0.0442) 0.9908 1.035; σ's not completely resolved			
	Z_c (0.0333) 1.000 1.033			
9	6678.275	$^1P_1 - {}^3D_2$	*b*	[(0) (8) 31 39 47]/30
	Z_o (0) (0.260) 1.035 1.297 **1.559**			
	Z_c (0) (0.2667) 1.033 1.300 1.567			
15	6598.953	$^1P_1 - {}^3P_1$	*c*	[(9) 31 40]/30
	Z_o (0.2996) 1.0343 1.335; Z_c (0.300) 1.033 1.333			
6	6532.881	$^3P_0 - {}^1P_1$	*d*	[(0) 2]/3; Z_o (0) 0.6639; Z_c (0) 0.667
15	6506.527	$^3P_1 - {}^1D_2$	*a*	[(0) (5) 12 17 22]/15
	Z_o (0) (0.3289) **0.8064** 1.137 1.468			
	Z_c (0) (0.333) 0.800 1.133 1.467			
20	6402.246	$^3P_2 - {}^3D_2$	*a*	[(0) (1) (2) 6 7 8 9 10]/6
	Z_o (0) (0.1643) (0.3286) **0.9951** 1.164 1.334 1.503 1.672			
	Z_c (0) (0.1667) (0.333) 1.000 1.1667 1.333 1.500 1.667			
12	6382.991	$^3P_1 - {}^1P_1$	*c*	[10 (12) 22]/15
	Z_o 0.6689 (0.7875) 1.469; Z_c 0.667 (0.800) 1.467			
10	6334.428	$^3P_2 - {}^1D_2$	*c*	[(11) (22) 23 34 45 56]/30
	Z_o (0.3670) (**0.7340**) 0.7723 **1.139 1.497** 1.845			
	Z_c (0.367) (0.733) 0.767 1.133 1.500 1.867			
6	6304.789	$^3P_1 - {}^3P_2$	*a*	[(0) (7) 30 37 44]/30
	Z_o (0) (0.2272) **0.9964** 1.235 1.473			
	Z_c (0) (0.233) 1.000 1.233 1.467			
15	6266.495	$^3P_0 - {}^3D_1$	*d*	[(0) 1]/1; Z_o (0) 0.9937; Z_c (0) 1.00
15	6217.279	$^3P_2 - {}^1P_1$	*b*	[(0) 4 (5) 9 14]/6
	Z_o (0) 0.6680 (0.8228) 1.4985 **2.329**			
	Z_c (0) 0.667 (0.833) 1.500 2.333			
12	6163.594	$^3P_0 - {}^3P_1$	*d*	[(0) 4]/3; Z_o (0) 1.339; Z_c (0) 1.333
12	6143.061	$^3P_2 - {}^3P_2$	*c*	[(8) (16) 29 37 45 53]/30
	Z_o (0.2718) (**0.5436**) 0.9646 **1.233 1.499** 1.768			
	Z_c (0.2667) (0.5333) 0.9667 1.233 1.500 1.767			
6	6128.457	$^3P_1 - {}^3D_1$	*c*	[(7) 15 22]/15
	Z_o (0.4730) 0.9860 1.455; Z_c (0.4667) 1.000 1.467			
8	6096.162	$^3P_1 - {}^3D_2$	*a*	[(0) (5) 34 39 44]/30
	Z_o (0) (0.1650) **1.133** 1.303 1.474			
	Z_c (0) (0.1667) 1.133 1.300 1.467			
10	6074.337	$^3P_1 - {}^1S_0$	*d*	[(0) 22]/15; Z_o (0) 1.465; Z_c (0) 1.467
10	6029.999	$^3P_1 - {}^3P_1$	*c*	[(2) 20 22]/15
	Z_o (0.1240) 1.333 1.470; Z_c (0.133) 1.333 1.467			
12	5975.534	$^3P_2 - {}^3D_1$	*b*	[(0) (1) 2 3 4]/2
	Z_o (0) (0.4902) 1.025 1.516 2.007			
	Z_c (0) (0.500) 1.000 1.500 2.000			
10	5944.834	$^3P_2 - {}^3D_2$	*c*	[(2) (4) 11 13 15 17]/10
	Z_o (0.204) (**0.409**) 1.101 **1.304 1.506** 1.708			
	Z_c (0.200) (0.400) 1.100 1.300 1.500 1.700			
20	5881.896	$^3P_2 - {}^3P_1$	*b*	[(0) (1) 8 9 10]/6
	Z_o (0) (0.1533) 1.349 1.505 **1.662**			
	Z_c (0) (0.1667) 1.333 1.500 1.667			
50	5852.487	$^1P_1 - {}^1P_0$	*d*	[(0) 31]/30; Z_o (0) 1.034; Z_c (0) 1.033

Pb_{82} (15); spectral structure (81, 82)

		Pb *I*		
4	5005.45	$2p^1S_0 - 3s^1P_1$	*	[(0) 17]/15; Z_o (0) 1.112; Z_c (0) 1.133
3	4168.04	$2p^1D_2 - 3d^3D_3$		[11 (13) 24 (26) 37 50]/30
	Z_o 0.367 (0.428) **0.796** (**0.856**) 1.234 1.656			
	Z_c 0.367 (0.433) 0.800 (0.866) 1.233 1.667			
4	4062.15	$2p^1D_2 - 3d^1D_1$		[(0) (1) 26 37 43]/30
	Z_o (0) (0.366) 0.865 1.232 **1.597**			
	Z_c (0) (0.367) 0.867 1.233 1.600			

Pb_{82}.—(*Continued*)

Int.	λ	Terms	4	Type
		Pb *I*.—(*Continued*)		
6	4057.92	$2p^3P_2 - 2s^3P_1$		[(0) (1) 18 19 20]/15
	Z_o (0) (0.075) **1.194**		$\frac{1}{5}$†	
	Z_c (0) (0.067) 1.200 1.267 1.333			
3	4019.62	$2p^1D_2 - 3d^3F_3$	$\frac{1}{10}$†	[(0) (7) 14 53 60 67 74 81]/60
	Z_o (0) (0.102) 0.202 **0.913** 1.015			
	Z_c (0) (0.117) 0.233 0.883 1.000 1.117 1.233 1.350			
5	3740.00	$2p^1D_2 - 3s^3P_2$		[(8) (16) 29 37 45 53]/30
	Z_o (0.269) (0.538) 0.957 **1.225 1.490** 1.752			
	Z_c (0.267) (0.533) 0.967 **1.233 1.500** 1.767			
6	3683.47	$2p^3P_1 - 2s^3P_0$		[(0) 3]/2; Z_o (0) 1.494; Z_c (0) 1.500
3	3671.50	$2p^1D_2 - 3s^3P_1$	$\frac{1}{10}$†‡	[(0) (3) 34 37 40]/30
	Z_o (0) (0.066) **1.149** 1.255			
	Z_c (0) (0.100) 1.133 1.233 1.333			
	Better			[(0) (2) 35 37 39]/30
	Z_c (0) (0.067) 1.167 1.233 1.300			
6	3639.57	$2p^3P_1 - 2s^3P_1$		[(1) 8 9]/6
	Z_o (0.166) 1.336 1.502; Z_c (0.167) 1.333 1.500			
5	3572.77	$2p^1D_2 - 3s^1P_1$		[(0) (3) 34 37 40]/30
	Z_o (0) (0.113) 1.142 1.239 **1.337**			
	Z_c (0) (0.100) 1.133 1.233 1.333		$\frac{1}{10}$†	
4	2873.29	$2p^3P_2 - 3d^3D_2$		[(7) (14) 5 12 19 26]/15
	Z_o (0.477) (**0.953**) 0.316 **0.796 1.269** 1.748			
	Z_c (0.467) (0.934) 0.333 0.800 1.267 1.734			
6	2833.06	$2p^3P_0 - 2s^3P_1$	§	[(0) 4]/3; Z_o (0) 1.340; Z_c (0) 1.333
4	2823.20	$2p^3P_2 - 3d^3F_2$	T_{ps}—	[(0) (1) (2) 74 75 76 77]/60
	Z_o (0)		1.260	
	Z_c (0) (0.017) (0.034) 1.233 1.250 1.267 1.284			
5	2802.01	$2p^3P_2 - 3d^3F_3$	*s*, *r*	[(0) (9) (18) 49 58 67 76 85]/60
	Z_o (0) (0.155) (0.310) **0.808** 0.962 1.116 1.271			
	Z_c (0) (0.150) (0.300) 0.817 0.967 1.117 1.267 1.417			
4	2663.17	$2p^3P_2 - 3s^3P_2$		[(7) (14) 31 38 45 52]/60
	Z_o (0.221) (**0.442**) 1.039 **1.266 1.493** 1.719			
	Z_c (0.233) (0.466) 1.033 1.267 1.500 1.733			
5	2614.20	$2p^3P_1 - 3d^3F_2$	‖	[(0) (1) 4 5 6]/4
	Z_o (0) (**0.249**) 0.995 1.246 1.499			
	Z_c (0) (0.250) 1.000 1.250 1.500			
3	2613.68	$2p^3P_1 - 3d^3D_1$	¶	[(19) 26 45]/30
	Z_o (0.632) 0.793 1.507; Z_c (0.633) 0.864 1.500			
4	2577.28	$2p^3P_2 - 3s^1P_1$		[(0) (2) 17 19 21]/15
	Z_o (0) (0.147) 1.135 1.270 **1.420**			
	Z_c (0) (0.133) 1.131 1.267 1.400			
4	2476.39	$2p^3P_1 - 3s^3P_2$	/	[(0) 3]/2; Z_o (0) 1.506; Z_c (0) 1.500
4	2446.20	$2p^3P_1 - 3s^3P_1$		[(1) 8 9]/6
	Z_o (0.188) 1.307 1.495; Z_c (0.167) 1.333 1.500			
	(Better) Z_c (0.200) 1.300 1.500			[(2) 13 15]/10
4	2443.84	$2p^3P_1 - 3s^3P_0$		[(0) 3]/2; Z_o (0) 1.505; Z_c (0) 1.500
4	2401.94	$2p^3P_1 - 3s^1P_1$		[(11) 34 45]/30
	Z_o 0.378 1.126 1.505; Z_c 0.367 1.133 1.500			
5	2393.80		**	
		Pb *II* Int. (60)		
10	6660.05			[(2) 4]/3; Z_o (0.669) 1.340; Z_c (0.667) 1.333
15	5608.90			[(1) 3 5]/3
	Z_o (0.336) **0.988** 1.656; Z_c (0.333) 1.000 1.667			
5	2203.41			[(1) 3 5]/3
	Z_o (0.324) 1.004 1.682; Z_c (0.333) 1.000 1.667			

* Deviation 2 %.
† Distance of components; the unit is *o* = normal resolution.
‡ Distorted, but completely resolved.
§ Reversed in Pb-arc, sharp in Sn-arc.
‖ Distorted by λ = 2613.68.
¶ Distorted by λ = 2614.20. Very asymmetric. Calculated type is based on 4062 and 3639, and accords with distorted type of 2613.
** Not resolved; type considered similar to that of 2802.

Pt_{78} (97); Int. (108); Terms (97, 139, 151); terms in ( ) are uncertain

		Pt *I*		
6	5478.50			Z_o (0) 1.33
6	5475.78			Z_o (0.32) 1.26
4	5390.80			Z (0) 1.38
2	5387.88			Z_o (0.45) 0.88

Pt_{78}.—(*Continued*)

Int.	λ	Terms	4	Type
		Pt *I.*—(*Continued*)		
4	5368.99	$^3\overline{F}_2 - (F_3)$		$g_x = .0.92$, $g_y = 1.19$
	Z_o (0) (0.27) (0.55)		1.73	
	Z_c (0) (0.27) (0.54) 0.65 0.92 1.19 1.46 **1.73**			
	5328.60			Z_o (0) 1.03
0	5324.59	$^3P_1 - (\overline{D}_2)$		Z_o (0) 1.51
0	5319.34			Z_o (0) 1.05
6	5301.02			Z_o (0) 1.15
3	5260.86	$^1G_4 - (F_3)$		Z_o (0) 0.81
0	5257.48			Z_o (0) 1.29
6	5227.66	$^3P_2 - (D_2)$		$g_x = 1.19$,* $g_y = 1.37$*
	Z_o (0.36)	1.29		
	Z_c (0.18) (**0.36**) 1.01 **1.19 1.37** 1.55			
	5199.26			Z_o (0) (1.05)
1	5193.91			Z_o (0) (1.03)
	5130.91	$(^3D_1) - (P_0)$		$g_x = 0.50$, $g_y = 0$
	$Z_o = Z_c$ (0) 0.50			
1	5118.44	$^1D_2 - (\overline{D}_2)$		Z_o (0) 1.00
	5108.45			Z_o (0) 1.10
0*d*	5095.82			Z_o (0) 1.08
	5082.35			Z_o (0) 1.12
5	5059.50			Z_o (0) 1.24
4	5033.54			Z_o (0) 1.15
2	5002.65			Z_o (0) 1.34
2	4997.98			Z_o (0) 0.95
	4940.15			Z_o (0) 1.15
4	4879.55			Z_o (0.31) 1.23
0	4862.40			Z_o (0.33) 1.17
4	4853.93			Z_o (0) 1.50
1	4831.97			Z_o (0) 1.26
1	4772.32			Z_o (0) 1.37
	4768.12			Z_o (0) 0.79
2	4737.50	$^1D_2 - (P_1$ or $\overline{D}_1)$		$g_x = 1.00$, $g_y = 1.50$
	Z_o (0) (0.50) **0.50** 1.02 1.52			
	Z_c (0) (0.50) **0.50** 1.00 1.50			
4	4684.10	$^3F_2 - (\overline{D}_1)$		$g_x = 0.92$,* $g_y = 1.13$*
	Z_o (0)	0.86		
	Z_o (0) (0.21) **0.71** 0.92 1.13			
5	4657.95			Z_o (0) 1.46
1	4650.07			Z_o (0) 1.15
4	4640.82	$(F_2) - (^3D_1)$		$g_x = 0.82$,* $g_y = 0.50$*
	Z_o (0)	1.13		
	Z_c (0) (0.32) 0.50 0.82 **1.24**			
4	4577.42	$^3F_2 - (\overline{D}_2)$		$g_x = 0.92$,* $g_y = 1.17$*
	Z_o (0.35)	1.2		
	Z_c (0.21) (**0.50**) 0.67 **0.92 1.17** 1.42			
4	4554.59	$^3P_1 - (\overline{D}_2)$		$g_x = 1.42$,* $g_y = 1.40$*
	Z_o (0)	1.35		
	Z_c (0) (0.02) **1.38** 1.40 1.42			
5*d*	4552.42			Z_o (0.36) 1.2
5*d*	4523.00			Z_o (0) 1.23
5*d*	4520.91			Z_o (0) 1.20
1	4515.66			Z_o (0) 1.61
6	4498.75			Z_o (0) 1.13
3	4493.16			Z_o (0) (0.57) 1.12 1.75
2	4486.73			Z_o (0) 1.23
5*r*	4484.72			Z_o (0) 1.20
3	4481.64	$^3P_1 - (P_0)$		$g_x = 1.42$; $g_y = 0$
	$Z_o = Z_c$ (0) 1.42			
1	4480.33			Z_o (0.63) 1.29
3*d*	4473.45			Z_o (0) 1.36
1	4465.13			Z_o (0.31) 1.24
3	4458.65			Z_o (0) 1.04
1	4457.06			Z_o (0) 0.92
4	4445.56	$^3D_1 - (\overline{D}_2)$		$g_x = 0.45$, $g_y = 1.37$
	Z_o (0) (0.88) 0.45 1.39 **2.21**			
	Z_c (0) (0.88) 0.50 1.37 **2.24**			
6	4442.52	$^3F_3 - (\overline{D}_2)$		$g_x = 1.03$, $g_y = 1.37$
	Z_o (0) (0.33) (0.68) **0.33** 0.68 1.04 1.36 1.69			
	Z_c (0) (0.34) (0.68) **0.35** 0.69 1.03 1.37 1.71			
4*d*	4437.31			Z_o (0) 1.28
3	4430.24			Z_o (0) 1.10
2	4414.28			Z_o (0) 1.55
3	4411.43			Z_o (0) 1.34
4	4364.46			Z_o (0) 0.80
2*d*	4358.36			Z_o (0.22) 1.09
0	4343.70			Z_o (0) (0.57) 1.15 1.74
2	4334.70			Z_o (0) 0.95
4	4327.07			Z_o (0) 1.37

Pt_{78}.—(*Continued*)

Int.	λ	Terms	4	Type
		Pt *I.*—(*Continued*)		
	4309.18			Z_o (0) 1.51
	4304.91			Z_o (0) 1.10
2	4290.97			Z_o (0) 1.10
4	4288.08	$^3F_2 - (F_3)$		$g_x = 0.92$,* $g_y = 0.82$
	Z_o (0.23)	0.90		
	Z_c (0.10) (**0.20**) 0.72 **0.82 0.92** 1.02			
1	4281.78	$^3\overline{P}_2 - (\overline{D}_1)$		$g_x = 1.20$,* $g_y = 1.13$*
	Z_o (0)	1.21		
	Z_c (**0**) (0.07) 1.13 1.20 **1.27**			
2	4269.25			Z_o (0) 1.03
2	4263.53			Z_o (0) 1.04
	4259.97			Z_o (0) 1.57
1	4251.16			Z_o (0) 0.88
2	4201.14			Z_o (0) 1.06
4	4192.43	$^3P_2 - (\overline{D}_2)$		$g_x = 1.20$,* $g_y = 1.17$*
	Z_o (0)	1.16		
	Z_c (0.03) (0.06) 1.14 **1.17 1.20** 1.23			
4	4164.54	$^3\overline{F}_3 - (F_3)$		$g_x = 1.04$,* $g_y = 1.19$*
	Z_o (0.36)	0.92	1.41	
	Z_c (0.15) (0.30) (**0.45**) 0.74 0.89 **1.04 1.19** 1.34 1.49			
5	4118.69			Z_o (0) (0.60) 1.42 1.67
1	4081.48			Z_o (0) 1.29
2	4065.94			Z_o (0.37) 1.25
2	4054.78			Z_o (0) 1.21
	4000.72			Z_o (0) 1.05
3	3996.59	$^3F_2 - (\overline{D}_2)$		$g_x = 0.92$, $g_y = 1.40$
	Z_o (0.51) (**0.92**) 0.42 **0.92 1.41** 1.90			
	Z_c (0.49) (**0.98**) 0.43 **0.92 1.41** 1.90			
3	3966.35			Z_o (0.53) 1.52
1	3953.63			Z_o (0.75) 1.56
4	3948.38	$^3\overline{P}_2 - (F_2)$		$g_x = 1.20$, $g_y = 0.82$
	Z_o (0.34) (**0.73**) **0.73** **1.20** 1.58			
	Z_c (0.38) (**0.76**) 0.44 **0.82 1.20** 1.58			
4	3925.34			Z_o (0) 1.33
5	3922.97			Z_o (0) 1.34
3	3910.90			Z_o (0) 1.23
2	3906.27			Z_o (0) 1.02
4	3898.74			Z_o (0.36) 1.36
4	3819.88			Z_o (0) 1.08
5	3818.69			Z_o (0) 1.36
2	3720.74			Z_o (0) 1.15
3	3706.54			Z_o (0.41) 1.04
4	3699.89	$^3\overline{P}_2 - (\overline{D}_2)$		$g_x = 1.20$,* $g_y = 1.40$*
	Z_o (0.44)	**1.27** 1.61		
	Z_c (0.20) (**0.40**) 1.00 **1.20 1.40** 1.60			
4	3687.45			Z_o (0) 1.36
4	3683.02			Z_o (0) 1.54
4	3674.05	$^3D_1 - (\overline{D}_2)$		$g_x = 0.59$, $g_y = 1.17$
	Z_o (**0**) (0.60) 1.15 **1.76**			
	Z_c (0) (0.58) 0.59 1.17 **1.76**			
4	3672.00			$g_x = 1.04$,* $g_y = 1.17$*
	Z_o (0)	1.00		
	Z_c (**0**) (0.13) (0.26) **0.78** 0.91 1.04 1.17 1.30			
1	3668.39			Z_o (0) 0.98
4	3663.09			Z_o (0) 1.18
1	3652.26			Z_o (0) 1.35
6	3643.16			Z_o (0) 1.16
6	3638.78			Z_o (0) 1.20 1.80
3	3628.84			Z_o (0) 1.30
5	3628.11			Z_o (0) 1.34
2	3610.91	$^3F_2 - (P_1$ or $D_1)$		$g_x = 0.92$,* $g_y = 1.50$*
	Z_o (0)	1.01		
	Z_c (**0**) (0.48) **0.34** 0.82 1.50			
3	3587.38	$^3\overline{P}_1 - (P_0)$		$g_x = 1.50$, $g_y = 0$
	Z_o (0) 1.49; Z_c (0) 1.50			
6	3485.27	$^3D_1 - (F_2)$		$g_x = 0.49$, $g_y = 0.87$
	Z_o (**0**) (0.38)	0.88 **1.25**		
	Z_c (**0**) (0.38) 0.49 0.87 **1.25**			
5	3483.42	$^3\overline{F}_3 - (F_2)$		$g_x = 1.04$,* $g_y = 0.87$*
	Z_o (0)	1.43		
	Z_c (**0**) (0.17) (0.34) 0.70 0.87 1.04 1.21 **1.38**			
	3464.43			Z_o (0) 0.81
4	3427.94			Z_o (0) 1.16
	3421.72			Z_o (0.29) 1.02
2	3417.05			Z_o (0) 0.87
4	3343.90			Z_o (0) 0.48
6	3323.80			Z_o (0) 1.60
4	3315.03			Z_o (0) 1.72

Pt_{78}.—(*Continued*)

Int.	λ	Terms	4	Type
		Pt *I*.—(*Continued*)		
6	3290.20	$^3D_1 - (\overline{D}_2)$		$g_x = 0.51$, $g_y = 1.39$
	Z_o (**0**) (0.86) 1.36 **2.27**			
	Z_c (**0**) (0.88) 0.51 1.39 **2.27**			
4	3268.38			Z_o (0) 1.28
4	3261.67			Z_o (0) 1.00
2	3261.08			Z_o (0) 1.29
4	3259.72			Z_o (0) 0.93
6	3255.93	$^1S_0 - (\overline{D}_1)$		$g_x = 0$, $g_y = 1.13$
	$Z_o = Z_c =$ (0) 1.13			
5	3251.97	$^3D_1 - (P_0)$		$g_x = 0.46$, $g_y = 0$
	$Z_o = Z_c =$ (0) 0.46			
4	3250.33			Z_o (0) 1.39
5	3240.20			Z_o (0) 1.03
5	3230.29			Z_o (0) 1.17
6	3204.06			Z_o (0) 1.31
4	3200.69			Z_o (0) 1.13
5	3156.56	$^3D_1 - (P_1)$		$g_x = 0.50$, $g_y = 1.10$
	Z_o (0.60) 1.10			
	Z_c (**0.60**) 0.50 **1.10**			
6*R*	3064.69	$^3D_2 - (\overline{D}_2)$		$g_x = 1.33$,* $g_y = 1.37$*
	Z_o (0) 1.25			
	Z_c (**0**) (0.02) (0.04) **1.30** 1.32 1.33 1.35 1.37			
4*R*	3042.63			Z_o (0) **1.61**
7*R*	2997.97	$^1D_2 - (F_3)$		$g_x = 1.00$,* $g_y = 1.19$*
	Z_o (0) (?) 1.15			
	Z_c (**0**) (0.19) (0.38) 0.81 1.00 1.19 1.38 **1.57**			
4	2989.80			Z_o (0) **1.45**
2	2983.74			Z_o (0.72) 2.13
4	2959.09			Z_o (0) 1.59
8*R*	2929.79			Z_o (0) 1.64
3	2921.40			Z_o (0) 1.39
4	2919.35	$^3P_2 - (F_3)$		$g_x = 1.20$,* $g_y = 1.19$
	Z_o (0) 1.16			
	Z_c (**0**) (0.30) **0.90** 1.20 1.50			
4	2913.57			Z_o (0) (0.82) 2.02
2	2913.30			Z_o (0) 1.11
4	2905.90			Z_o (0) 1.10
5	2897.89			Z_o (0) 1.26
6	2893.87			Z_o (0) 1.66
4	2893.26			Z_o (0) 1.00
4	2888.20			Z_o (0) 1.15
4	2870.47			Z_o (0) 1.51
2	2839.23			Z_o (0) 1.34
8*R*	2830.29			Z_o (0) 1.52
4	2818.23			Z_o (0) 1.23
6	2803.22	$^1S_0 - (P_1)$		$g_x = 0$, $g_y = 1.04$; $Z_o = Z_c =$ (0) 1.04
5*R*	2794.20			Z_o (0) 1.42
4	2793.28			Z_o (0) 1.28
4	2773.99			Z_o (0) 1.45
4	2773.28			Z_o (0) 1.28
4*R*	2771.65			Z_o (0) 1.12
4	2754.90			Z_o (0) 1.33
4	2747.59			Z_o (0) 1.21
4	2738.45			Z_o (0) 1.17
8*R*	2733.96			Z_o (0) 1.20
6*R*	2719.02			Z_o (0) 1.42
4	2713.09			Z_o (0) 1.65
5*R*	2705.88			Z_o (0) 1.51
6	2698.40	$^1S_0 - (P_1$ or $\overline{D}_1)$		$g_x = 0$, $g_y = 1.49$; $Z_o = Z_c =$ (0) 1.49
4	2694.20			Z_o (0) 1.29
5*R*	2677.13			Z_o (0) 1.71
4	2674.54			Z_o (0) 1.58
10*R*	2659.44			Z_o (0.40) 1.20
4*R*	2650.84			Z_o (0) 1.55
6*R*	2646.87			Z_o (0) 1.43
5	2639.83			Z_o (0) 1.27
4	2619.56			Z_o (0) 1.29
4	2596.00			Z_o (0) 1.55
4	2505.93			Z_o (0) 1.69

* This value is assumed known from other calculations.

Rh_{45} (229)

Rh *I*

4	4842.40	$^4P_3 - (^4\overline{F}_4)$		
	Z_o (0.00) 0.50			
	Z_c (**0.14**) (0.40) (0.77) **0.66** 0.99 1.20 1.46 1.74 2.00			
7	4675.03	$^2F_4 - {}^4D_4$		
	Z_o 0.98			
	Z_c (0.14) (0.43) (0.71) (**1.00**) 0.43 0.71 1.00 **1.28** 1.57 1.86 2.14			

Rh_{45}.—(*Continued*)

Int.	λ	Terms	4	Type
		Rh *I*.—(*Continued*)		
5	4569.01	$^4P_3 - {}^4G_4$		
	Z_o (0.25) 0.00 **0.49**			
	Z_c (**0.31**) (0.93) (1.55) 0.05 **0.57** 0.67 1.29 1.91 2.53			
5	4528.74	$^2F_3 - {}^4\overline{F}_4$		
	Z_o (0.00) 1.76			
	Z_c (**0.18**) (0.57) (0.95) 0.29 0.67 1.05 1.43 1.81 **2.19**			
5	4379.93	$^4P_3 - {}^2D_3$		
	Z_o (0.71) 1.21			
	Z_c (0.20) (0.60) (**1.00**) 0.66 1.00 **1.40** 1.80 2.20			
7	4374.81	$^2F_4 - {}^4G_5$		
	Z_o (0.00) 1.26			
	Z_c (**0.02**) (0.06) (0.10) (0.14) 1.02 1.06 1.10 1.14 1.18 1.22 1.26 **1.30**			
7	4288.72	$^2F_3 - {}^4G_4$		
	Z_o (0.00) 1.21			
	Z_c (**0.00**) (0.19) (0.32) 0.67 0.80 0.92 1.05 1.18 **1.30**			
5	4211.15	$^2F_4 - {}^4F_5$		
	Z_o (0.00) 1.74			
	Z_c (**0.01**) (0.29) (0.48) (0.67) 0.67 0.86 1.05 1.24 1.43 1.62 1.81 **2.00**			
3	4196.51	$^4P_2 - {}^2G_4$		
	Z_o (0.41) 0.87			
	Z_c (**0.35**) (1.06) (1.77) 0.17 0.54 **0.88** 1.25 1.95 2.66			
4	4135.30	$^2F_4 - {}^4\overline{F}_4$	*Ts*	
	Z_o (0.00) 1.15			
	Z_c (0.05) (0.14) (**0.33**) 0.91 1.00 1.10 **1.19** 1.28 1.38 1.48			
6	4128.93	$^2F_3 - {}^2\overline{F}_4$		
	Z_o (0.00) 1.59			
	Z_c (0.14) (0.43) (0.71) 0.43 0.71 1.00 1.29 1.57 **1.86**			
4	4121.72	$^2F_3 - {}^2D_3$		
	Z_o (0.00) 1.00			
	Z_c (0.17) (0.51) (**0.86**) 0.34 0.69 **1.03** 1.37 1.71			
4	4077.59	$^2\overline{D}_3' - (^4D_2')$	*	Z_o (0.00) 1.30; Z_c (0.00) 1.20
5	3996.16	$^2P_2 - (^4D_2')$	*	
	Z_o (0.00) 1.10			
	Z_c (**0.03**) (0.07) 1.30 1.35 1.40 **1.44**			
4	3995.62	$^4P_2 - {}^4\overline{P}_3$		
	Z_o (0.00) 1.33			
	Z_c (**0.06**) (0.19) **1.41** 1.54 1.66 1.79			
5	3984.41	$^4P_2 - {}^4\overline{P}_2$		Z_o (0.19) 1.52; Z_c (0.00) 1.73
5	3975.32	$^2\overline{D}_2' - (^4D_2')$	*	Z_o (0.00) 1.19; Z_c (0.00) 1.20
5	3958.86	$^2F_3 - {}^2G_4$		
	Z_o (0.00) 1.07			
	Z_c (**0.02**) (0.05) (0.08) 0.81 0.84 0.87 0.91 0.94 **0.97**			
5	3942.71	$^4P_2 - {}^4\overline{P}_1$	†	
	$g_{x_o} = 1.56$, $g_{y_o} = 2.06$			
	$g_{x_c} = 1.73$, $g_{y_c} = 2.67$			
4	3934.23	$^2F_4 - {}^4G_4$		
	Z_o (0.44) 1.09			
	Z_c (0.08) (0.24) (**0.55**) 0.54 0.75 0.90 **1.06** 1.22 1.38 1.54			
4	3922.18	$^2\overline{D}_2 - {}^4D_1$		Z_o (0.36) 0.36 1.09; Z_c (0.40) 0.40 **1.20**
4	3856.51	$^2F_4 - {}^2G_5$		
	Z_o (0.00) 1.19			
	Z_c (**0.02**) (0.05) (0.08) (0.12) **1.00** 1.03 1.06 1.09 1.13 1.16 1.19 1.22			
5	3833.87	$^2F_3 - {}^2D_2$		
	Z_o (0.00) 0.97			
	Z_c (0.03) (0.09) 0.77 0.83 0.89 **0.94**			
2	3828.47	$^4P_3 - {}^4\overline{P}_3$	*Ts*	Z_o (0.00) 1.48; Z_c (0.00) 1.60
4	3822.25	$^2F_3 - {}^2\overline{F}_3$		Z_o (0.16) 0.99; Z_c (0.00) 0.86
5	3818.20	$^4P_3 - {}^4\overline{P}_2$	*Ts*	
	Z_o (0.00) 1.46			
	Z_c (**0.06**) (0.19) **1.41** 1.54 1.66 1.79			
1	3816.46	$^2\overline{D}_2' - (^2\overline{F}_3')$	*	
	Z_o (0.00) 1.09			
	Z_c (**0.03**) (0.09) 0.77 0.83 0.89 0.94			
4	3806.77	$^4F_3 - {}^4D_2$		
	Z_o 0.60 1.16			
	Z_c (0.17) (0.51) (**0.86**) 0.51 0.86 **1.20** 1.54 1.89			
4	3805.92	$^2\overline{D}_3' - {}^2D_2^1$		Z_o (0.28) 1.19; Z_c (0.00) 1.20
4	3799.32	$^2F_4 - {}^2\overline{F}_4$	*Ts'*	Z_o (0.00) 1.12; Z_c (0.00) 1.14
4	3793.22	$^2F_4 - {}^2D_3$		
	Z_o (0.00) 1.56			
	Z_c (0.03) (0.09) (0.14) **1.00** 1.06 1.12 1.17 1.23 1.29			
5	3788.58	$^2\overline{D}_3 - {}^2D_3$	†	
	$g_{x_o} = 1.15$, $g_{y_o} = 0.88$			
	$g_{x_c} = 1.20$, $g_{y_c} = 0.80$			
5	3765.08	$^2F_4 - {}^4G_5$	†	
	$g_{x_o} = 1.19$, $g_{y_o} = 0.98$			
	$g_{x_c} = 1.14$, $g_{y_c} = 0.57$			

Rh_{45}.—(*Continued*)

Int.	λ	Terms	4	Type
		Rh *I*.—(*Continued*)		
5	3748.23	$^4P_2 - {}^4D'_4$		
	Z_o (0.20)	**0.60** 0.98 1.40 1.82		
	Z_c (**0.18**) (0.54) **0.83** 1.19 1.55 1.92			
4	3744.18	$^2P_2 - (^4D^2_3)$	*	
	Z_o (0.00) 1.26			
	Z_c (0.06) (**0.19**) 1.39 1.26 1.14			
4	3735.28	$^2\overline{D}'_3 - (^2\overline{F}'_4)$	*	
	Z_o (0.00) 1.19			
	Z_c (**0.03**) (0.09) (0.14) **1.00** 1.06 1.12 1.17 1.23 1.29			
8	3700.90	$^4F_4 - {}^4G_5$		
	Z_o (0.00) 1.15			
	Z_c (**0.03**) (0.10) (0.17) (0.23) **0.94** 1.00 1.07 1.14 1.20 1.27 1.33 1.40			
5	3698.61	$^2\overline{G}_5 - (^2\overline{F}^2_4)$	*	
	Z_o (0.00) 1.02			
	Z_c (**0.02**) (0.05) (0.08) (0.11) **1.00** 1.03 1.06 1.09 1.13 1.16 1.19 1.22			
3	3698.27	$^4P_1 - {}^4D'_2$		
	Z_o (**0.77**) 0.37 1.91			
	Z_c (**0.73**) **0.47** 1.93			
10	3692.36	$^4F_5 - {}^4D_4$		
	Z_o (0.00) 1.27			
	Z_c (**0.05**) (0.14) (0.24) (0.33) **1.00** 1.10 1.19 1.28 1.38 1.48 1.57 1.67			
4	3690.72	$^2\overline{D}_3 - {}^4D_2$	*Ts*	Z_o (0.00) 1.06; Z_c (0.00) 1.20
6	3681.06	$^2P_2 - (^2D^2_3)$	*	
	Z_o (0.00) 1.40			
	Z_c (**0.07**) (0.20) **1.00** 1.14 1.27 1.40			
5	3674.77	$^4P_1 - {}^2\overline{P}_2$		Z_o (**0.63**) 0.63 1.92
				Z_c (**0.67**) 0.67 1.99
4	3666.92	$^2P_2 - {}^2\overline{P}^2_2$	*Ts*	Z_o (0.00) 1.26; Z_c (0.00) 1.33
7	3666.23	$^4F_3 - {}^4\overline{F}_4$	*Ts*	
	Z_o (0.00) 1.18			
	Z_c (0.10) (0.31) (0.52) 0.71 0.92 1.13 1.34 1.55 **1.76**			
3	3661.88	$^2\overline{G}_4 - (^4\overline{F}'_4)$	*	
	Z_o (0.00) 0.69			
	Z_c (0.06) (0.17) (0.28) **0.62** 0.73 0.85 0.96 1.07 1.18			
8	3658.00	$^4F_4 - {}^4D_3$		
	Z_o (0.00) 1.19			
	Z_c (**0.07**) (0.20) (0.33) **0.90** 1.04 1.17 1.31 1.44 1.57			
6	3639.53	$^4P'_1 - {}^4D'_1$		$Z_o = Z_c =$ (1.33) 1.33
7	3626.61	$^4P_2 - {}^4D'_4$		
	Z_o (0.00) 1.01			
	Z_c (**0.09**) (0.26) (0.43) 1.00 1.17 1.34 1.52 1.69 1.86			
5	3620.47	$^2F_2 - {}^4\overline{P}_2$		
	Z_o (0.20) 0.20 0.72			
	Z_c (**0.37**) (1.11) **0.25** 0.49 1.23 1.97			
4	3614.78	$^2\overline{G}_4 - (^2\overline{F}^2_3)$	*	
	Z_o (0.00) 0.81			
	Z_c (**0.02**) (0.05) (0.08) 0.81 0.84 0.87 0.91 0.94 **0.97**			
5	3612.47	$^4F_2 - {}^4D_1$		Z_o (**0.23**) 0.23 0.69
				Z_c (**0.20**) 0.20 **0.60**
5	3605.88	$^4P_2 - {}^4D'_3$	†	
	$g_{x_o} =$ 1.60, $g_{yo} =$ 1.17			
	$g_{x_c} =$ 1.73, $g_{yc} =$ 1.20			
6	3597.15	$^2\overline{D}_3 - {}^4G_4$		
	Z_o (0.00) 0.72			
	Z_c (**0.11**) (0.33) (0.55) **0.43** 0.65 0.87 1.09			
4	3596.19	$^4F_3 - {}^4D_2$		
	Z_o (0.00) 1.02			
	Z_c (**0.09**) (0.26) **0.77** 0.94 1.11 1.29			
4	3583.09	$^4F_4 - {}^4\overline{F}_5$		
	Z_o (0.00) 1.36			
	Z_c (**0.05**) (0.14) (0.24) (0.33) 1.00 1.10 1.19 1.29 1.38 1.48 1.57 **1.67**			
4	3570.18	$^4F_2 - {}^4\overline{F}_3$	†	
	$g_{x_o} =$ 0.84, $g_{yo} =$ 0.47			
	$g_{x_c} =$ 1.03, $g_{yc} =$ 0.40			
5	3543.97	$^2\overline{D}_2 - {}^2D_3$		Z_o (0.24) 0.85; Z_c (0.00) 0.80
4	3541.92	$^4P_1 - {}^2\overline{P}^2_2$		Z_o (0.64) 0.64 1.95; Z_c (0.67) 0.67 1.99
7	3528.03	$^4F_4 - {}^4\overline{F}_4$		Z_o (0.28) 1.23; Z_c (0.00) 1.24
4	3513.11	$^2P_1 - {}^2\overline{P}^2_2$		Z_o (0.33) **1.73** 1.03
				Z_c (0.33) **1.67** 1.00
4	3507.32	$^4F_3 - {}^4G_4$		
	Z_o (0.00) 0.91			
	Z_c (**0.02**) (0.07) (0.11) **0.87** 0.92 0.96 1.01 1.05 1.10			
8	3502.54	$^4F_5 - {}^4G_5$		
	Z_o (0.63) 1.30			
	Z_c (0.08) (0.24) (0.40) (0.57) (**0.73**) 0.61 0.77 0.93 1.04 **1.26** 1.42 1.58 1.74 1.90			
7	3498.74	$^4F_2 - {}^2D_3$	†	
	$g_{x_o} =$ 0.52, $g_{yo} =$ 1.03			
	$g_{x_c} =$ 0.40, $g_{yc} =$ 1.20			

Rh_{45}.—(*Continued*)

Int.	λ	Terms	4	Type
		Rh *I*.—(*Continued*)		
4	3484.04	$^2\overline{D}_3 - {}^2\overline{F}_4$	*Ts*	
	Z_o (0.00) 1.12			
	Z_c (**0.03**) (0.08) (0.14) **1.00** 1.06 1.12 1.17 1.23 1.29			
4	3478.91	$^2\overline{D}_3 - {}^2D_3$		Z_o (0.30) 1.07; Z_c (0.00) 1.20
5	3474.79	$^4F_2 - {}^4G_3$	†	
	$g_{x_o} =$ 0.94, $g_{yo} =$ 0.48			
	$g_{x_c} =$ 0.57, $g_{yc} =$ 0.40			
4	3470.67	$^4F_2 - {}^4\overline{F}_2$		Z_o (0.14) 0.53; Z_c (0.00) 0.40
4	3462.04	$^4F_3 - {}^4\overline{F}_3$	†	
	$g_{x_o} =$ 1.08, $g_{yo} =$ 0.80			
	$g_{x_c} =$ 1.03, $g_{yc} =$ 1.03			
	3434.90	$^4F_5 - {}^4G_6$		
	Z_o (0.60) 1.18			
	Z_c (**0.03**) (0.09) (0.15) (0.21) (0.27) **1.00** 1.06 1.12 1.18 1.24 **1.30** 1.36 1.42 1.49 1.55			
7	3399.68	$^4F_3 - {}^2\overline{F}_4$	*Ts*	
	Z_o (0.00) 1.13			
	Z_c (**0.06**) (0.17) (0.29) 0.86 0.97 1.09 1.20 1.32 **1.43**			
8	3396.82	$^4F_5 - {}^4\overline{F}_5$		Z_o (0.28) 1.34; Z_c (0.00) 1.33
	3372.84	$^4F_3 - {}^4G_3$		
	Z_o (0.42) 1.03			
	Z_c (0.23) (0.69) (**1.14**) 0.11 0.34 **0.80** 1.26 1.71			
6	3368.38	$^4F_3 - {}^4\overline{F}_2$	†	
	$g_{x_o} =$ 1.04, $g_{yo} =$ 0.48			
	$g_{x_c} =$ 1.03, $g_{yc} =$ 0.40			
6	3323.09	$^4F_4 - {}^2G_5$		
	Z_o (0.00) 1.07			
	Z_c (**0.06**) (0.19) (0.32) (0.44) **0.67** 0.79 0.92 1.05 1.18 1.30 1.42 1.55			
4	3283.57	$^4F_3 - {}^2G_4$		
	Z_o (0.00) 0.67			
	Z_c (**0.06**) (0.17) (0.28) **0.62** 0.73 0.85 0.96 1.07 1.18			
4	3280.54	$^4F_4 - {}^2\overline{F}_4$		
	Z_o 0.39 1.25			
	Z_c (0.05) (0.14) (0.24) (**0.32**) 0.91 1.00 1.10 **1.19** 1.28 1.38 1.48			
8	3271.61	$^2\overline{D}_3 - {}^2D_2$		
	Z_o (0.00) 1.38			
	Z_c (**0.20**) (0.60) 0.60 1.00 1.40 **1.80**			
8	3263.14	$^2\overline{D}_3 - {}^2\overline{F}_3$		
	Z_o (0.28) 1.05			
	Z_c (0.17) (0.51) (0.86) 0.34 0.69 **1.03** 1.37 1.71			
6	3191.18	$^2\overline{D}_2 - {}^4D'_3$	†	
	$g_{x_o} =$ 1.24, $g_{yo} =$ 0.81			
	$g_{x_c} =$ 1.37, $g_{yc} =$ 0.80			

* Second term—(D), (F)—not positively established.

† If type deviates from the theoretical one, the author gives only g-values.

Sc_{21} (**86**); Int. and λ (**64**); *cf.* (**147**); spectral structure (**38, 40, 80, 86, 146, 149**)

		Sc *I*		
10	4047.81	$^2D_3 - {}^2D'_2$		[(**1**) (3) 5 7 **9**]/5
	Z_o **1.77** 1.39 0.98 (0.59) (**0.19**) (**0.19**) (0.56) 0.96 1.33 **1.71**			
	Z_c **1.80** 1.40 1.00 (0.60) (**0.20**) (**0.20**) (0.60) 1.00 1.40 **1.80**			
30	4023.68	$^2D_3 - {}^2D'_3$	*s*	[(0) 6]/5
	Z_o 1.21 (0) 1.21; Z_c 1.20 (0) 1.20			
20	4020.40	$^2D_2 - {}^2D'_2$	*s*	[(0) 4]/5
	Z 0.80 (0) 0.81; Z_c 0.80 (0) 0.80			
15	3996.61	$^2D_2 - {}^2D'_3$		[(**1**) (3) 5 7 **9**]/5
	Z_o **1.79** 1.40 1.00 (0.62) (**0.19 0.19**) (0.56) 0.98 1.40 **1.76**			
	Z_c **1.80** 1.40 1.00 (0.60) (**0.20**) (**0.20**) (0.60) 1.00 1.40 **1.80**			
30	3911.88	$^2D_2 - {}^2F'_4$	s_i*	[(**1**) (3) (5) **35** 37 39 41 43 45]/35
	Z_o 1.07 (0) 1.06; Z_c 1.00 (0) 1.00			
30	3907.54	$^2D_2 - {}^2F_3$	*s*—*	[(**1**) (3) 27 29 31 **33**]/35
	Z_o 0.90 (0) 0.91; Z_c 0.94 (0) 0.94			
5	3269.84	$^2D_2 - {}^2P_1$	*W, d*	[(1) 11 **13**]/15
	Z_o 0.87 (0) 0.76			
	Z_c 0.86 0.74 (0.07) (0.07) 0.74 0.86			
		Sc *II*		
20	4415.55	$^3F'_2 - {}^3F_2$	*s*	[(0) 2]/3
	Z_o 0.69 (0) 0.67; Z_c 0.67 (0) 0.67			
20	4400.39	$^3F'_3 - {}^3F_3$	*s*	[(0) 13]/12
	Z_o 1.09 (0) 1.10; Z_c 1.08 (0) 1.08			
30	4374.51	$^3F'_4 - {}^3F_4$	*s*	[(0) 5]/4
	Z_o 1.28 (0) 1.37; Z_c 1.25 (0) 1.25			
20	4325.00	$^3F'_2 - {}^3D'_1$	s_o*	[(**0**) (1) 3 4 **5**]/6
	Z_o 0.79 (0) 0 79; Z_c 0.83 (0) 0.83			
20	4320.75	$^3F'_3 - {}^3D'_2$	s_i*	[(**0**) (1) (2) (3) **11** 12 13 14 15 16]/12
	Z_o 0.98 (0) 0.96; Z_c 0.92 (0) 0.92			

Sc_{21}.—(*Continued*)

Int.	λ	Terms	4	Type
		Sc *II*.—(*Continued*)		
30	4314.09	$^3F'_4 - {}^3D'_3$	s_4*	[(0) (1) (2) (3) **12** 13 14 15 16 17 18]/12
	Z_o 1.09 (0) 1.10; Z_c 1.00 (0) 1.00			
50	4246.88		$s-$	Z_o 0.99 (0) 0.98
20	3651.99	$^3D_2 - {}^3F_2$	†‡	[1 (3) **4** (**5**) **7** 10]/6
	Z_o 1.58 1.00 0.57 0.57 1.04 1.67			
	Z_c 1.67 **1.17** (**1.00**) **0.67** (0.50) 0.16 0.16 (0.50) **0.67** (**1.00**) 1.17 1.67			
15	3645.48	$^3D_3 - {}^3F_3$	⊥ *D**	[(3) (6) (**9**) 7 10 **13 16** 19 22]/12
	Z_o (?) 0.69 0.68 (?)			
	Z_c 1.21 (0.75) (0.75) 1.21			
50	3642.96	$^3D_1 - {}^3F_2$	*B*, s_6*	[(**0**) (1) 3 4 **5**]/6
	Z_o 0.78 (0) 0.77; Z_c 0.83 (0) 0.83			
100	3630.75	$^3D_2 - {}^3F_3$	s_4*§	[(**0**) (1) (2) (3) **11** 12 13 14 15 16]/12
	Z_o 1.03 (0) 1.03; Z_c 0.92 (0) 0.92			
100	3613.83	$^3D_3 - {}^3F_4$	s_4*	[(**0**) (1) (2) (3) **12** 13 14 15 16 17 18]/12
	Z_o 1.11 (0) 1.12; Z_c 1.00 (0) 1.00			
10	3590.52	$^3D_3 - {}^3D'_3$	s_6*‖¶	[(**0**) (1) (2) 6 7 8 9 **10**]/6
	Z_o 1.42 (0) 1.51; Z_c 1.67 (0) 1.67			
10	3589.67	$^3D_2 - {}^3D'_1$	‡¶	[(**0**) 3 **4** 7 **11**]/6
	Z_o **1.83** 1.17 0.65 (**0**) 0.61 1.18 **1.76**			
	Z_c **1.83** 1.17 (0.67) 0.50 (**0**) 0.50 (0.67) 1.17 **1.83**			
20	3580.98	$^3D_1 - {}^3D'_1$	s	[(**0**) 1]/2
	Z_o 0.51 (0) 0.51; Z_c 0.50 (0) 0.50			
30	3576.37	$^3D_2 - {}^3D'_2$	s	[(**0**) 7]/6
	Z_o 1.14 (0) 1.19; Z_c 1.17 (0) 1.17			
50	3572.57	$^3D_3 - {}^3D'_3$	s	[(**0**) 4]/3
	Z_o 1.31 (0) 1.34; Z_c 1.33 (0) 1.33			
20	3567.72	$^3D_1 - {}^3D'_2$	‡	[(**0**) 3 (4) 7 **11**]/6
	Z_o **1.83** 1.16 0.64 (**0**) 0.64 1.15 **1.82**			
	Z_c **1.83** 1.17 (0.67) 0.50 (**0**) 0.50 (0.67) 1.17 **1.83**			
20	3558.56	$^3D_2 - {}^3D'_3$	s_6*	[(**0**) (1) (2) **6** 7 8 9 10]/6
	Z_o 1.63 (0) 1.64; Z_c 1.67 (0) 1.67			
10	3535.74			Z_o 1.98 (0) 1.02
10	3372.16	$^3D_3 - {}^3P_1$	s_4*	[(**0**) (1) (2) **6** 7 8 9 10]/6
	Z_o 1.16 (0) **1.13**; Z_c 1.00 (0) 1.00			
8	3359.69	$^3D_2 - {}^3P_1$	⊥ D*	[(2) (**4**) 5 **7 9** 11]/6
	Z_o (?) 0.66 0.66 (?)			
	Z_c 1.33 (0.67) (0.67) 1.33			
20	3353.74		*d*	Z_o 1.00 (0) 1.00

* Only strongest components of Z_c are given decimally.
† Asymmetric; inner components too weak.
‡ Measured on plate with two states of polarization.
§ Splitting-up is too great, *cf.* λ = 4320.75.
‖ Splitting-up is too simple, *cf.* λ = 3558.56.
¶ The 1.42 of λ = 3590.52 coincides with the **1.76** of λ = 3589.67.

Sn_{50} (92); *cf.* (16); spectral structure (16, 92, 141, 175, 203, 264)

		Sn *I*; Int. (64); λ (16); Terms (92)		
3	5631.69	$3s^2P'_1 - 2p^1S'_0$		$Z_o = Z_c$ = (0) 1.38
15	4524.74	$3s^1P'_1 - 2p^1S'_0$		$Z_o = Z_c$ = (0) 1.115
30	3801.031	$3s^3P'_1 - 2p^1D'_2$		$Z_o = Z_c$ = (0) (0.34) 0.715 1.06 1.40
5	3655.78	$3d^3D_1 - 2p^1S'_0$		$Z_o = Z_c$ = (0) 0.64
20	3330.60	$3s^3P'_2 - 2p^1D'_2$		
	Z_o (0.44) (0.89) 0.59 1.07 1.51 1.96			
	Z_c (0.45) (0.90) 0.60 1.06 1.51 1.96			
100	3262.33	$3s^1P'_1 - 2p^1D'_2$		
	Z_o (0) 1.01			
	Z_c (0) (0.07) 0.97 1.04 1.12			
3	3218.690	$4s^3P'_2 - 2p^1S'_0$	*	$Z_o = Z_c$ = (0) 1.32
100	3175.039	$3s^3P'_1 - 2p^3P_2$		
	Z_o (0) 1.50			
	Z_c (0) (0.07) 1.38 1.45 1.53			
5	3141.81	(?)$3d^3P_1 - 2p^1S'_0$		$Z_o = Z_c$ = (0) 1.22
6*R*	3034.16	$3S^3P'_0 - 2p^3P_1$		$Z_o = Z_c$ = (0) 1.51
8	3032.78	$3d^1P'_1 - 2p^1S'_0$		$Z_o = Z_c$ = (0) 1.055
50	3009.138	$3s^3P'_1 - 2p^3P_1$	†	Z_o (0.12) 1.44 Z_c (0.12) 1.38 1.50
10	2913.542	$4d^3D_1 - 2p^1S'_0$		$Z_o = Z_c$ = (0) 0.845
20	2863.320	$3s^3P'_1 - 2p^3P_0$		$Z_o = Z_c$ = (0) 1.38
10	2850.61	$3d^3D_2 - 2p^1D'_2$		
	Z_o (0.30) 0.94			
	Z_c (0.19) (0.38) 0.67 0.86 1.05 1.24			
30	2839.99	$3s^3P'_2 - 2p^3P_2$		
	Z_o (0) 1.50			
	Z_c (0.05) (0.10) 1.42 1.47 1.52 1.57			

Sn_{50}.—(*Continued*)

Int.	λ	Terms	4	Type
		Sn *I*.—(*Continued*)		
4	2813.58	$3d^3F'_2 - 2p^1D_2$		
	Z_o (0) 1.09			
	Z_c (0) (0.08) (0.16) 1.05 1.13 1.21			
3	2785.027	$3d^3D_1 - 2p^1D'_2$		Z_o (0) 1.39
4	2779.814	$3d^3F'_3 - 2p^1D'_2$		
	Z_o (0) 1.30			
	Z_c (0) (0.12) (0.23) 0.935 1.05 1.17 1.28 1.39			
10	2706.50	$3s^3P'_2 - 2p^3P_1$		$Z_o = Z_c$ = (0) 1.51
3	2661.25	$3s^1P'_1 - 2p^3P_1$		Z_o (0.38) 1.15 1.50 Z_c (0.38) 1.14 1.51
5	2571.60	$3d^3D_3 - 2p^1D'_2$	‡	
	Z_o 1.46			
	Z_c (0) (0.19) (0.38) 0.86 1.05 1.24 1.43 1.62			
1	2456	$3d^3F'_2 - 2p^3P_2$		Z_o 1.01 (0) 1.24 Z_c 1.125 (0) 1.125
6	2421.70	$3d^1F'_3 - 2p^1D'_2$		
	Z_o (0) 1.00			
	Z_c (0) (0.025) (0.050) 0.975 1.000 1.025 1.050 1.075			
4	2334.799	$3d^3D_1 - 2p^3P_1$		Not resolved, but $j_1 = j_2$
		Sn *II*; Int. and λ (175); Terms (92)		
20	6452.79	$6^2S_1 - 6^2P_2$		Z_o (0.36) 1.01 1.66; Z_c (0.33) 1.00 1.67
25	5799.35	$5^2D_{23} - 4^2F_{34}$		Z_o (0) 1.07
8	5598.15	$6^2P_2 - 6^2D_2$		
	Z_o (0.80) 0.55 1.06 1.60			
	Z_c (0.27) (0.80) 0.53 1.07 1.60			
30	5589.44	$5^2D_2 - 4^2F_3$		Z_o (0) 0.90
30	5562.92	$6^2P_2 - 6^2D_3$		
	Z_o (0) 1.04			
	Z_c (0.07) (0.20) 1.00 1.13 1.27			
30	5333.23	$6^2P_1 - 6^2D_2$		Z_o (0) 0.835 Z_c (0.07) 0.73 0.87
30	3352.42	$p^2D_3 - 4^2F_{34}$	*cf.* λ = 5799	Z_o (0) 1.06
30	3283.54	$p^2D_2 - 4^2F_3$	*cf.* λ = 5589	Z_o (0) 0.91
		Sn *III*; Int. (64)		
3	5369.5	$6^3P_0 - 5^3D_1$		Z_o (0) 0.48; Z_c (0) 0.50
4	5349.37	$6^3P_1 - 5^3D_2$		
	Z_o (0) 0.96			
	Z_c (0) (0.33) **0.83** 1.17 1.50			
1	5291	$6^3P_1 - 5^3D_1$		Z_o (0.95) 0.47 1.41; Z_c (1.00) 0.50 1.50
5	5224.92	$5^1D_2 - 6^1P_1$	*D*	Z_o (0) 1.04; Z_c (0) 1.00
7	5100.56	$6^3P_2 - 5^3D_3$		
	Z_o (0) 1.10			
	Z_c (0) (0.16) (0.33) **1.00** 1.17 1.33 1.50 1.67			
1	5020.7	$6^3P_2 - 5^3D_2$		
	Z_o (0.67) 1.29			
	Z_c (0.33) (0.67) 0.83 **1.17 1.50** 1.83			
6	4924.12	$6^3S_1 - 6^3P_0$		Z_o (0) (1.97); Z_c (0) 2.00
6	4858.12	$6^3S_1 - 6^3P_1$		Z_o (0.55) 1.49 2.02; Z_c (0.50) 1.50 2.00
0	4715.82	$5^3D_2 - 6^1P_1$		
	Z_o (0) 1.20			
	Z_c (0) (0.16) 1.00 1.16 **1.33**			
20	4585.62	$6^3S_1 - 6^3P_2$		
	Z_o (0) (0.50) **1.02** 1.52			
	Z_c (0) (0.50) **1.00** 1.50 2.00			
5	4330.13	$6^3S_1 - 6^1P_1$		Z_o (0.93) 0.99 2.00; Z_c (1.00) 1.00 2.00
	3550	$^3P'_2 - {}^1P_2$	*D*§	
	Z_o (0) 1.75			
	Z_c (0) (0.50) 1.00 1.50 **2.00**			

* Very asymmetric. † Outside components are resolved, but not measurable.
‡ Shaded symmetrically. § Obscured by lines of band.

V_{23} (24); Int. (119); λ (64, 112); Terms (24, 42, 80, 127, 144)

		V *I*		
7	6266.28	$^6D'_3 - {}^6F'_2$		
	Z_o (0.25) (0.67) 1.40 1.91 2.38			
	Z_c (**0.30**) (0.89) 0.77 1.36 1.95 **2.54**			
5	6261.18	$^6D'_2 - {}^6F'_1$		Z_o 0.78 (1.12) 3.05; Z_c 0.60 (**1.27**) **3.13**
2	6245.14	$^6D'_1 - {}^6F'_1$		Z_c 1.47 (1.94); Z_c **1.33** (**2.00**)
6	6240.09	$^6D'_3 - {}^6F'_2$		
	Z_o 0.84 (1.05) 1.50 2.21			
	Z_c (0.40) 0.67 (**1.20**) **1.47** 2.27			
12	6233.10	$^6D'_2 - {}^6F'_2$		
	Z_o 0.74 1.42			
	Z_c (**0.17**) (0.51) 0.80 (**0.86**) 1.14 **1.49** 1.83 2.17			

V_{23}.—(*Continued*)

Int.	λ	Terms	4	Type
		V *I*.—(*Continued*)		
1	6221.18	$^6P'_4 - {}^4D'_3$		
	Z_o 0.54			
	Z_c **0.17** (**0.52**) 0.86 (1.54) 1.88			
15	6213.83	$^6D'_5 - {}^6F'_5$		
	Z_o 0.45 1.48			
	Z_c (0.06) (0.18) (0.30) (0.42) (**0.54**) 1.01 1.13 **1.25** 1.37 **1.49** 1.62 1.74 1.86 1.98			
1	6190.49	$^6P'_3 - {}^4D'_3$		
	Z_o 1.16			
	Z_c (0.26) 0.60 (0.77) 1.12 (**1.29**) **1.63** 2.14 2.66			
3	6189.34	$^6D'_3 - {}^6F'_4$		
	Z_o (?) 1.00			
	Z_c (**0.13**) (0.39) (0.65) **0.75** 1.01 1.27 1.62 1.79 2.05			
15	6150.11	$^6D'_5 - {}^6F'_6$		
	Z_o (?) 1.14			
	Z_c (**0.05**) (0.15) (0.25) (0.35) (0.45) **1.00** 1.10 1.20 1.30 1.40 1.50 1.60 1.70 1.80 1.90			
2	6017.94	$^4P_2 - {}^4D_2$		
	Z_o 0.74 0			
	Z_c 0.27 (**0.80**) 0.93 **1.46** 2.00			
1	6008.68	$^4P_1 - {}^4D_1$		Z_o 1.26 (1.40); Z_c 1.33 (1.33)
2	6002.30	$^4P_3 - {}^4D_4$		
	Z_o (?) 1.16			
	Z_c (**0.09**) (0.26) (0.43) **1.00** 1.17 1.34 1.52 1.69 1.86 1.94			
3	5980.81	$^4P_2 - {}^4D_3$		
	Z_o ? 1.02			
	Z_c (0.18) 0.54 **0.83** 1.19 1.55 1.92			
1	5610.20	$^4F_5 - {}^6F'_4$		
	Z_o (0) 1.26			
	Z_c (**0.03**) (0.09) (0.16) (0.22) **1.11** 1.18 1.24 1.30 1.36 1.43 1.49 1.56			
1	5593.02	$^4F_4 - {}^6D_3$		
	Z_o (?) 1.49			
	Z_c **0.19** (**0.21**) 0.62 (0.66) 1.03 (1.05) 1.45 1.86 2.29			
1	5588.47	$^4D'_4 - {}^6D_4$		
	Z_o (0.48) 1.55			
	Z_c (0.08) (0.24) (0.40) (**0.56**) 1.03 1.19 1.35 **1.51** 1.67 1.83 1.99			
1+	5578.33	$^4D'_2 - {}^6D_1$		Z_o 0 (1.06); Z_c **0.13** (1.03) 2.27
1	5573.98	$^4F_4 - {}^6F'_3$		
	Z_o (0) 1.10			
	Z_c (**0.04**) (0.11) (0.19) **1.04** 1.12 1.20 1.28 1.35 1.43			
1	5565.93	$^4D'_2 - {}^6D_2$		
	Z_o (?) 1.59			
	Z_c (0.33) 0.87 (**1.00**) **1.54** 2.20			
4	5547.04	$^4D'_4 - {}^6D_5$		
	Z_o (0) 1.77			
	Z_c (**0.06**) (0.19) (0.32) (0.44) 1.11 1.24 1.36 1.49 1.62 1.75 1.87 **2.00**			
2	5545.91	$^4D'_3 - {}^6D_4$		
	Z_o (0) 1.92			
	Z_c (**0.11**) (0.32) (0.54) 1.05 1.26 1.49 1.70 1.92 **2.13**			
1	5542.69	$^4F_3 - {}^6F_2$		
	Z_o (0) 0.96			
	Z_c (**0.02**) (0.06) **0.97** 1.01 1.05 1.08			
1	5517.18	$^4F_2 - {}^6F'_1$		Z_o (0.42) 0.79; Z_c (0.53) **0.93**
1	5515.05	$^4F_5 - {}^6F'_6$		0.13
	Z_o (?) 1.74			
	Z_c **0.06** (0.18) (0.30) (0.42) (0.55) 0.91 1.03 1.15 1.27 1.40 1.52 1.64 1.76 1.88 **2.00**			
4	4932.03	$^4P_3 - {}^4P'_2$		
	Z_o (0) 1.52			
	Z_c (**0.07**) (0.20) **1.40** 1.53 1.67 1.80			
10	4925.66	$^4P_3 - {}^4P'_3$		Z_o (0) 1.62; Z_c (0) 1.60
2	4886.82	$^4P_2 - {}^4P'_2$		Z_o (0) 1.74; Z_c (0) 1.73
8	4880.56	$^4P_2 - {}^4P'_3$		
	Z_o (0) 0.90 1.65			
	Z_c (**0.07**) (0.20) **1.40** 1.53 1.67 1.80			
12	4412.16	$^6D'_1 - {}^4P'_1$		Z_o (0.37) 2.94; Z_c (**0.33**) **3.00**
5	4392.10	$^6D'_2 - {}^4P'_2$		
	Z_o 1.98 1.76			
	Z_c (0.07) (**0.20**) 1.67 **1.80** 1.93			
5	4363.53	$^6D'_3 - {}^4P'_3$		$Z_o = Z_c =$ (0) 1.60
5	4124.09	$^4P_3 - {}^{(4)}D_3$	*	
	Z_o (0.55) 1.11			
	Z_c (0.20) (0.60) 0.60 (**1.00**) 1.00 **1.40** 1.80 2.20			
4	4107.48	$^4P_2 - {}^{(2)}D_2$	*	
	Z_o 0.39 (0.43) 1.26 (1.35)			
	Z_c 0.33 (0.47) **1.26** (**1.40**) 2.20			
3	4092.40	$^4P_1 - {}^{(2)}D_2$	*	
	Z_o (0.17) (0.55) 0.76 1.14 1.50			
	Z_c (**0.27**) (**0.40**) 0.80 0.93 1.47 2.00			

V_{23}.—(*Continued*)

Int.	λ	Terms	4	Type
		V *I*.—(*Continued*)		
2	4070.78	$^4F_5 - {}^6F'_5$		
	Z_o 0.38 1.32			
	Z_c (0.05) (0.15) (0.25) (0.35) (**0.45**) 0.97 1.07 1.17 1.27 **1.37** 1.48 1.58 1.68 1.78			
2	4068.00	$^4F_3 - {}^6F'_2$		
	Z_o (0) 1.03			
	Z_c (**0.04**) (0.11) (0.19) **1.04** 1.12 1.20 1.28 1.35 1.43			
1	4052.47	$^4F_4 - {}^6F'_4$		
	Z_o 0.53 (?)			
	Z_c (0.08) (0.24) (0.40) (**0.56**) 0.84 1.00 1.16 **1.32** 1.48 1.74 1.90			
2	4048.61	$^4F_3 - {}^6F'_3$		
	Z_o (0) 0.98			
	Z_c (**0.02**) (0.06) (**0.99**) 1.03 1.08 1.12			
1	4032.85	$^4F_2 - {}^6F'_1$		Z_o (?) 0.90
				Z_c 0.13 (0.53) **0.94**
12	3943.65	$^4D'_4 - {}^2D$		
	Z_o (0) 1.44			
	Z_c (**0.11**) (0.34) (0.57) 0.86 1.09 1.31 1.54 1.77 **2.00**			
5	3936.32	$^4D'_3 - {}^2D_2$		
	Z_o (**0.29**) 0.51 (0.86) 1.09 1.66 **2.23**			
	Z_c (0.26) 0.48 (0.77) 1.09 1.60 2.08			
12	3922.46	$^4D'_3 - {}^2D_3$		
	Z_o (0) 1.33			
	Z_c (0.09) (0.26) (**0.43**) 0.94 1.11 **1.29** 1.46 1.62			
5	3920.49	$^4D'_2 - {}^2D_2$		
	Z_o 0.53 0.60 0.98 1.40			
	Z_c (0.20) (**0.60**) 0.60 **1.00** 1.40			
5	3910.78	$^4D'_1 - {}^2D_2$		Z_o (0.39) 0.41 1.20; Z_c (**0.40**) 0.40 **1.20**
6	3906.75	$^4D'_1 - {}^2D_2$		Z_o (0) 1.44; Z_c (0) 1.20
6	3397.50	$^4P_3 - {}^4P'_2$		
	Z_o (0) 1.48			
	Z_c (**0.07**) (0.20) **1.40** 1.53 1.67 1.80			
15	3377.61	$^4P_3 - {}^4P'_3$		Z_o (0) 1.49; Z_c (0) 1.60
10	3377.37	$^4P_2 - {}^4P'_1$		Z_o (0.45) 1.21 2.10; Z_c (**0.47**) **1.27** 2.20
8	3376.06	$^4P_2 - {}^4P'_2$		Z_o (0) 1.59; Z_c (0) 1.73
4	3366.88	$^4P_1 - {}^4P'_1$		Z_o (0) 2.54; Z_c (0) 2.66
10	3365.57	$^4P_1 - {}^4P'_2$		Z_o (0.46) 1.07 2.05; Z_c (**0.47**) 1.27 2.20
10	3356.36	$^4P_2 - {}^4P'_3$		
	Z_o (0) 1.38			
	Z_c (**0.07**) (0.20) **1.40** 1.53 1.67 1.80			
5	3259.53	$^4D'_3 - {}^4P'_2$		
	Z_o (0) 1.02			
	Z_c (**0.18**) (0.54) **0.83** 1.19 1.55 1.92			
9	3255.65	$^4D'_4 - {}^4P'_3$		
	Z_o (0) (?) 1.15			
	Z_c (**0.09**) (0.26) (0.43) **1.00** 1.17 1.34 1.52 1.69 1.86			
3	3243.29	$^4D'_1 - {}^4P'_1$		Z_o (1.30) 1.28; Z_c (**1.33**) **1.33**
4	3241.17	$^4D'_2 - {}^4P'_3$		
	Z_o (0.49) 1.43			
	Z_c (0.11) (0.34) (**0.57**) 1.03 1.26 **1.49** 1.72 1.95			

* The (4) and the (2) are uncertain.

W_{74} (**28**); Int. (**29**); λ (**29, 112**); spectral structure (**128**)

Int.	λ	Z_o
		W *I*
6	5514.712	(0.000) (1.041) 0.459 1.501 2.542
6	5224.680	(0.000) (0.435) (0.870) 0.734 1.069 1.504 **1.939** 2.374
8	5053.300	(0.968) 1.433 2.401
6	4843.829	(0.413) (0.826) 1.056 1.469 1.883 2.296
4	4757.565	(0.000) 2.046
6	4680.539	(0.280) (0.560) (0.840) 0.926 1.206 1.486 1.766 2.046 2.327
6	4659.886	(0.000) 2.532
8	4570.64	(0.000) (0.487) (0.974) 0.521 1.008 1.495 1.982 2.469
6	4484.197	(0.000) (0.417) 1.527 1.944 2.361
3	4460.523	(0.000) (0.534) 0.570 1.104 1.638
3	4378.501	(0.000) (0.360) (0.720) 2.090 2.450 2.810 3.170 3.530
6	4302.123	(0.241) (0.482) (0.723) 1.318 1.559 1.799 2.041 2.282 2.523
3	4274.554	(1.344) 1.612 2.956
5	4269.399	(0.000) (1.184) 2.367
6	4074.374	(0.253) (0.505) (0.758) 1.334 1.586 1.839 2.092 2.344 2.597
2	4071.939	(0.000) (0.371) 1.666 2.036 2.407
4	4070.618	(0.000) (0.324) (0.648) 0.931 1.255 1.579 1.903 2.227

W_{74}.—(*Continued*)

Int.	λ	Z_o
		W *I.*—(*Continued*)
5	4045.615	(0.000) (0.812) (1.624) 0.487 1.299 2.111 2.923 3.735
8	4008.769	(0.000) (0.312) (0.624)(0.936)0.853 1.171 1.483 1.795 2.107 2.419 2.731
5	3867.986	(0.000) (0.433) (0.865)(1.298) 0.405 0.838 1.270 1.703 2.136 2.659 3.001
5	3846.225	(0.000) (0.280) 0.976 1.256 1 .536
5	3835.058	(0.332) (0.663) 0.251 1.583 1.914 2.246
5	3768.448	(0.926) 1.636 2.562
6	3707.929	(0.737) (1.474) (2.211) 0.100 0.637 1.374 2.111 2.848 3.585
8	3617.522	(0.440) (0.880) (1.321) 0.891 1.331 1.771 2.211 2.652 3.092
4	3311.389	(0.000) (0.575) (1.150) 1.153 1.728 2.303 2.878 3.453
5	2964.520	(0.000) (0.545) (1.090) 1.225 1.770 2.315 2.868 3.414
8	2946.992	(0.590) (1.180) (1.769) 0.596 1.186 1.776 2.366 2.956 3.545
7	2944.410	(0.000) (0.499) (0.997) 1.312 1.810 2.306 2.804 3.303
6	2896.445	(0.000) (0.874) (1.748) 0.642 1.516 2.391 3.265 4.139
3	2848.029	(1.047) (2.094) (3.142) 0.784 0.263 1.311 2.358 3.406 4.453
4	2833.634	(0.000) (0.411) (0.822)(1.233) 0.474 0.885 1.296 1.707 2.118 2.529 2.940
5	2792.702	(1.163) (2.326) 0.037 1.127 2.290 3.453
		W *II*
3 (64)	4366.01	(0.190) 0.893 1.273
1 (64)	4343.24	(0.517) 1.762
	4335.39	(0.169) (0.508) 0.875 1.213 1.553 1.891
	4175.64	(0.237) 1.486 1.959
3	3657.590	(0.944) 1.780
1	3361.101	(0.932) 2.827
3	3117.580	(0.685) 1.433
4	2764.261	(1.466) 2.324
	2729.59	(1.065) 1.765
2	2658.05	(0.429) (1.288) 0.943 1.802 2.660

Int.	λ	B_o	Int.	λ	B_o	Int.	λ	B_o
	5617.03	1.204	3	4316.821	1.787	2	3177.187	1.603
	5616.16	0.934	3	4275.497	1.139	4	3163.419	1.344
	5604.31	1.730	2	4254.066	1.211	5	3041.876	1.474
	5487.74	1.807	3	4241.451	1.328	3	3039.320	1.137
	5477.82	1.406	2	4215.387	1.251	5	2997.794	1.628
3	5435.063	1.828	3	4204.415	1.214		2994.70	1.084
2	5388.023	1.612	3	4170.538	1.293	2	2936.680	1.090
1	5354.463	2.857	2	4154.678	1.741	5	2934.994	0.935
2	5259.356	2.087	3	4126.808	1.111		2925.81	0.862
3	5242.989	1.094		4125.69	1.251	3	2925.132	1.257
3	5192.725	1.046	3	4064.799	1.218	2	2918.633	1.145
4	5071.739	1.426	3	4028.798	1.591	4	2911.001	1.583
5	5054.615	1.430	3	3983.294	1.212	4	2896.010	1.610
6	5015.334	1.460	2	3979.293	1.204		2889.79	1.431
2	4986.943	1.458	1	3903.987	0.605	4	2856.033	1.585
6	4886.922	1.458	5	3809.239	0.994		2852.10	1.235
4	4729.664	1.916	2	3801.527	1.039	2	2805.930	0.863
3	4700.422	1.340	5	3641.419	1.296	3	2801.175	1.496
3	4677.710	1.200	4	3592.426	1.032	1	2740.799	0.999
2	4620.566	1.228	1	3572.477	1.450	1	2718.044	1.007
3	4543.524	1.405	1	3463.515	1.558	1	2716.323	1.528
2	4536.688	1.062	3	3429.604	1.213		2709.59	0.878
1	4492.334	1.028		3358.61	1.054		2706.72	1.221
	4441.80	1.169		3308.36	1.468		2703.49	1.280
2	4394.092	0.609		3304.46	1.195		2703.09	1.392
3	4384.868	1.228	3	3281.944	1.427	3	2697.727	2.011
3	4347.014	1.464		3262.25	1.162		2670.41	1.189
3	4330.670	1.261					2647.72	1.586

LITERATURE

(For a key to the periodicals see end of volume)

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(50) Curtis and Jevons, *58*, **116**: 746; 25. (51) Debye, *188*, **1916**: 142, 161. (52) Deslandres and d'Azambuja, *34*, **158**: 153; 14. (53) Dufour, *6*, **9**: 361; 06. (54) Dufour, *34*, **146**: 634; 08. (55) Dufour, *34*, **148**: 1311; 09. (56) Dufour, *34*, **150**: 614; 10. *199*, **7**: 74; 10. (57) Dufour, *51*, **9**: 277; 10. *250*, **1910**: 80. (58) Dufour, *199*, **8**: 97; 11. (59) Dufour, *51*, **1**: 189; 11.

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(120) King, *21*, **51**: 107; 20. (121) Körner, *63*, **13**: 797; 12. (122) Körner, *Diss.*, Göttingen, 1913. (123) Landé, *38*, **21**: 585; 19. (124) Landé, *96*, **5**: 231; 21. (125) Landé, *96*, **15**: 189; 23. (126) Landé, *63*, **24**: 441; 23. (127) Laporte, *63*, **24**: 510; 23. (128) Laporte, *218*, **13**: 627; 25. (129) Larmor, *3*, **44**: 503; 97.

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(170) Nagaoka and Mishima, *543*, **2**: 383; 26. (171) Nagaoka and Mishima, *543*, **2**: 479; 26. (172) Nagaoka and Sugiura, *437*, **2**: 1; 23. (173) Nagaoka and Takamine, *219*, **5**: 278; 10. (174) Nagaoka and Takamine, *219*, **7**: 188, 331; 14. *3*, **27**: 333; 14. **29**: 241; 15. (175) Narayan and Rao, *96*, **45**: 350; 27. (176) Oldenburg, *3*, **67**: 253; 22. (177) Paschen, *63*, **8**: 522; 07. (178) Paschen, *8*, **30**: 746; 09. (179) Paschen, *8*, **35**: 860; 11.

(180) Paschen, *149*, **35**: 403; 13. (181) Paschen, *8*, **60**: 405; 19. (182) Paschen, *8*, **63**: 201; 20. (183) Paschen and Back, *8*, **39**: 897; 12. **40**: 960; 13. (184) Paschen and Back, *208*, **1**: 261; 21. (185) Pauli, *96*, **16**: 155; 23. (186) Pauli, *96*, **31**: 373, 765; 25. (187) Peterke, *Diss.*, Halle, 1909. (188) Popov, *63*, **15**: 756; 14. (189) Popov, *8*, **45**: 147; 14.

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(200) Purvis, *63*, **8**: 594; 07. (201) Purvis, *201*, **15**: 45; 09. (202) Purvis, *21*, **34**: 312; 11. (203) Rao, *67*, **39**: 161; 27. (204) Reese, *3*, **43**: 317; 99. (205) Reese, *21*, **12**: 120; 00. (206) Ribaud, *34*, **154**: 1151; 12. (207) Richter, *Diss.*, Göttingen, 1914. (208) Righi, *63*, **1**: 329; 00. (209) Risco, *63*, **13**: 137; 12. *182*, **9**: 262; 11.

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POLE EFFECT

HAROLD D. BABCOCK

The term pole effect is used to designate the minute change of wave-length and the marked change of character which occur for many spectral lines when light from the central region of a metallic arc is compared with that originating near the electrodes. Much evidence indicates that under suitable conditions the central region of the arc gives the normal wave-length of a line, at least to a very close approximation. The phenomenon is accordingly considered to be a modification of the normal vibration frequency by some agency which is associated with proximity to the electrodes. It is manifested to the greatest degree by lines which are diffuse and unsymmetrical, and which, in some cases, show the greatest change of wave-length with increase of pressure.

In the spectrum of iron, for which the effect has been studied more extensively than for other elements, displacements amounting to 0.045Å toward the red and toward the violet have been observed for the lines λ4969.93 and λ5133.69 respectively, when light from near the negative pole was compared with that from the center of an ordinary iron arc. The average displacements for such lines in that region of the spectrum, however, are about one-half of the extreme value mentioned. Of 1570 iron lines examined between λ2979 and λ6678, 286 showed displacements toward the red at the negative pole and 80 were shifted in the opposite direction. These unstable lines, as a rule, require high temperature for their excitation, are reversed only under extreme conditions, and are associated with atomic transitions involving medium and high levels of atomic energy.

Lines showing no pole effect, or at most displacements barely distinguishable from errors of observation, are in general the most symmetrical, the most easily self-reversed, and the most readily excited by low temperature sources. They are members of multiplets which are produced by atomic transitions involving the lowest energy levels in iron atoms.

Goos (3) held that for iron the displacements at the pole are due to local increase of pressure above that in other parts of the arc. The measurements of St. John and Babcock (5), however, clearly indicate that this explanation is inadequate, and the recent work of Babcock (1) on pressure effect for iron shows conclusively that pole effect and pressure effect are distinct. A group of lines is cited which are displaced toward the violet by pole effect but in the opposite direction by increase of pressure. The pole effect for calcium has been found definitely related to spectral series by Gale and Whitney (2). Nagaoka (4) found no certain evidence of connection between pole effect and Zeeman effect.

There are many indications that pole effect is related to interatomic influences rather than to external causes directly under our control. The available data on Stark effect for iron point toward a correlation between this phenomenon and pole effect. Although no broad conclusions appear justified at present, it is possible that pole effect is nothing but Stark effect due to interatomic electrostatic fields whose efficacy depends upon various external conditions in the source.

The study of pole effect has developed a useful extension to the existing methods for classifying spectral lines, for which it affords a reliable criterion. Recognition of the rôle played by pole effect in many investigations which involve accurate knowledge of the positions of spectral lines has proved of distinct service. Mention may be made of the study of the pressure effect for terrestrial sources, and of the determination of pressures in the atmospheres of the sun and other stars, as examples. It is found in practice more satisfactory to eliminate the effect from the source of light than to attempt numerical correction for it in the results. For iron, at least, this is made feasible by suitable choice of conditions for operating the arc. The question is discussed in detail by St. John and Babcock (6), who found that enclosing the arc in a vacuum chamber caused the effect to disappear, and that under specified conditions the center of an arc at atmospheric pressure may also be used.

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EMISSION OF LIGHT BY SPARK DISCHARGES IN LIQUIDS

J. A. ANDERSON

The character of a spark discharge is determined by: (*a*) The current flowing through the spark gap. (*b*) The emf across the gap. (*c*) The material, size, shape and separation of the electrodes. (*d*) The medium in which the electrodes are immersed. Of these, this section is concerned more especially with (*a*) and (*d*).

The following general conclusions may be regarded as fairly well established:

1. With a moderately strong current[1] (condensed spark discharge) in water, there is a strong continuous spectrum extending through the visible region and into the ultra-violet at least as far as λ2300. Its intensity appears to be greatest in the near ultra-violet (region λ3000 to λ4000), and to be roughly independent of the material used as electrodes.

Superimposed on the continuous spectrum is one consisting of bright and dark lines, due chiefly to the electrodes. The low temperature arc lines appear as pure absorption lines. The high temperature arc lines, and a few of the more easily excited spark lines appear as more or less narrow absorption lines having bright edges, while the majority of spark lines are bright, generally broad, and often widened asymmetrically.

2. With decreasing current strength (smaller capacity or larger self-induction) the continuous spectrum diminishes rapidly in intensity, causing the pure absorption lines to become less conspicuous and finally to disappear. The bright lines narrow progressively, and those having bright edges gradually become narrow bright lines by the disappearance of their reversals. At low current values all lines are bright and relatively narrow, and the continuous spectrum is absent or very faint.

[1] As an example of a "moderately strong current," the experiments of L. and E. Bloch (2) may be cited. The capacity was 0.02 microfarad, the frequency of oscillation 570 000 cycles per sec. The potential is not stated, but must have been of the order of 20 000 volts. The maximum value of the current was accordingly about 1 400 amperes.

3. With the spark in water, the Balmer lines of hydrogen appear regularly as broad bright lines. In liquid hydrocarbons, the carbon bands appear in addition to the hydrogen lines. The air lines, so prominent in the ordinary spark spectrum, are absent.

The continuous spectrum originates in the core of the spark, and many observers have explained it as being due to hydrogen. Since Curie (3) found the continuous spectrum strongly developed with sparks in liquids containing no hydrogen, such as bromine, sulfur, etc., this explanation is probably incorrect. It is more probable that its origin is analogous to that of the continuous spectrum observed when wires are electrically exploded (*see* p. 434).

Bubbles of gas projected with considerable velocity from the spark are regularly observed and have sometimes been ascribed to electrolysis. Smith (15) was able to show that the quantity of gas liberated is many times too great to be accounted for in this way.

The condensed spark in water using electrodes of carbon or some of the metals is frequently used as a convenient source of continuous ultra-violet radiation, in the study of absorption spectra. A quartz window and a continuous renewal of the water surrounding the spark are necessary; *see also* (**1, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 16, 17, 18**).

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ELECTRICALLY EXPLODED WIRES

J. A. ANDERSON

A fine metallic wire a few centimeters in length, weighing 1 or 2 mg, is placed in the discharge circuit of a large condenser. During the discharge the wire is heated and vaporized so rapidly that the earlier observers of the phenomenon (2, 4) described it as an explosion. The mechanical effects of such an explosion are fully described by Singer (4) and Nipher (2). The explanation of the phenomenon recorded by Nipher is probably incorrect, since recent work has shown that the rapid evaporation of the wire is quite competent to account for all observed effects. For quite recent work, *see* (7, 8, 9, 10).

Circuit.—The constants of a circuit used by Anderson and by Smith are: Capacity (C) = 10^{-6} farad; inductance (L) = 3.35×10^{-6} henry; potential applied (V) = 2×10^4 volt; observed frequency of oscillation (N) = 87 000 cycles. If R be the total resistance of the circuit, including that of the wire, or of the vapor formed from it, the value of the current (i) at any time (t) is given by equation (1)

$$i = V\sqrt{\frac{C}{L}}\, e^{-\frac{Rt}{2L}} \sin 2\pi Nt \qquad (1)$$

$$= 10\ 900\, e^{-\frac{Rt}{2L}} \sin 2\pi Nt \text{ amp.}$$

The rate of development of heat energy in the wire is given by i^2r, and its maximum value is shown by the experiments to be above 10^7 watt.

Spectrum.—If the wire is in open air the spectrum consists of a moderately strong continuous background upon which is superposed a system of bright and dark lines. The latter are low and moderate temperature arc lines while the former are either spark or high temperature arc lines. If the wire is confined between two parallel planes placed 2 to 10 mm apart, few, if any, bright lines appear, the spectrum being continuous, with numerous absorption lines. All arc lines and many spark lines especially those of wavelength shorter than λ3000 are dark in the spectrum of an iron wire. The absolute brightness of the continuous spectrum is approximately equal to that of a black-body at 20 000°C.

Variation of Spectrum with Time (5).—During the first half oscillation the spectrum is continuous and without bright lines, but all arc lines and many belonging to the spark spectrum appear as absorption lines. In the succeeding half oscillation bright lines appear gradually, the enhanced lines first, followed in order by the high and medium temperature arc lines. In the later stages of the explosion, when the oscillations of the circuit are no longer discernible, even the low temperature arc lines appear bright.

Pressure.—In an open air explosion the pressure,[1] which initially is high, reaches a value of from 4 to 2 atm. at the end of the first half cycle, depending upon the size of wire employed. During the second half cycle it falls to a value not very much above that of the atmosphere. When the explosion is partially confined, the pressure falls more slowly, and is likely to be considerably above 1 atm. even during the second cycle. Hence it follows that at these high temperatures the spectrum is essentially continuous at pressures above 4 atm.; from 4 down to about 2 atm. the continuous spectrum diminishes somewhat in intensity, and below 2 atm. it weakens rapidly. Anderson (1) has shown that the vapors emitting a continuous spectrum have a high opacity, so that they appear to behave very much like a black-body.

[1] Computed from the measured values of mass and volume, assuming a temperature of 20 000°C.

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PHOTOMETRIC STANDARDS

E. C. CRITTENDEN

The standards of candlepower on which all precise photometry is based are groups of carbon-filament electric incandescent lamps maintained in several national laboratories. These lamps are burned at temperatures below those of ordinary operation so that they change very slowly with use. Since 1909 the laboratories of France, Great Britain, and the United States of America have thus maintained a common unit of candlepower variously known as the international candle, British candle, and bougie décimale. This unit, together with the procedure for maintaining it until a reproducible primary standard shall be evolved, has been accepted by the International Commission on Illumination, which includes representatives of Belgium, Italy, Spain, and Switzerland, in addition to the three countries named above. It is also used by the national laboratories of Japan and Russia, and has been adopted by the national standards committees in Australia, Canada, Czechoslovakia, Poland, and Sweden.

The Hefner candle, the unit used in the Germanic countries, is 0.9 of the international candle, this ratio being exact within the limits of accuracy with which comparisons have been made. The legal primary standard on which this unit is based is the Hefner lamp burning amyl acetate, but the light produced by any flame depends on atmospheric conditions. The precise value of the Hefner unit actually used was determined (3) in 1895 by comparisons between the flame lamps and electric lamps, and in recent years has been maintained by the electric standards, the flame standard serving as a check which would detect significant changes in the electric reference standards. No drift of the latter amounting to as much as 1% has been found (2, 3).

Secondary standards of the more recent types of electric incandescent lamps (tungsten-filament vacuum and gas-filled lamps) have been established by different procedures in the several national laboratories, and there are differences as large as 3 or 4 % between the values assigned to them. The adjustment of these differences depends upon the acceptance of a standard method of comparing lights of different colors. Experiments and comparative measurements leading toward such an agreement are in progress.

While flame standards of candlepower are now little used, individual lamps of two types (Hefner, and Vernon-Harcourt 10-candle pentane) are tested and certified by the national laboratories. The variation of their intensity with atmospheric conditions is commonly represented by an equation of the following form:

$$I = I_0[1 + a(e_0 - e) - c(760 - b)],$$

where e is the humidity expressed in liters of water vapor per cubic meter of dry air, e_0 is a normal humidity, b is the barometric pressure in millimeters of mercury, I_0 is the intensity (candlepower) of the particular lamp under normal atmospheric conditions, and I is the intensity under the conditions represented by observed values of e and b; it is assumed that variations of room temperature have a negligible effect. The accepted values of the constants are as follows:

Lamp	e_0	a	c	Lit.
Hefner	8.8	0.0055	0.00015	(3, 6)
Pentane:				
Great Britain	8.0	0.0063	0.0008	(1, 4)
United States	8.0	0.0057	0.0006	(5, 6, 7)
Japan	8.0	0.0064		(8)

The differences in the values of a for the pentane lamp arise from the fact that this "humidity factor" includes a temperature effect and that seasonal variations of humidity have a systematic relation to temperature which is nearly the same in England and Japan, but different in America. The real humidity factor is 0.0052; this combined with a temperature term, $+0.001(15 - t)$, brings observed results in the three countries into complete accord; t = room temperature, °C. The variation with barometric pressure is not actually linear, but over the range of natural pressure changes either the British or American coefficient gives results correct within the accuracy with which the lamp will reproduce its values.

For very complete bibliography, *see* (9).

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PHOTOMETRIC FILTERS

E. C. Crittenden

Introduction.—In visual photometry, filters are used (1) to equalize the intensity or the color of the two lights to be compared, (2) to test the characteristics of observers, (3) to transmit a spectral band so chosen that the ratio of its intensity to the integral light is the same for each of the lights (method of Crova). The Crova method can give correct results only when the filter is chosen in accordance with the spectral distribution of the particular sources to be compared. It is more convenient to use color equalizing filters, as they can be produced much more easily and no error is introduced by a failure in exactly equalizing the colors of the lights to be compared.

Equalizing Filters.—The color filters most commonly used are blue glasses and dyed gelatin films of a yellowish or amber tint. These are not reproducible; individual filters must be calibrated.

Continuously variable color filters using the rotatory dispersion of quartz plates between nicol prisms have been devised. The relative transmissions of these can be accurately calculated; *see* (5, 9).

Reproducible color-equalizing filters of known transmissions can be prepared from the following stock solutions. (*A*) Yellow solution: 100 g $Co(NH_4)_2(SO_4)_2.6H_2O$ + 0.733 g $K_2Cr_2O_7$ + 10 cm³ HNO_3 (d = 1.05 g/cm³) + H_2O to make 1 l of solution at 20°C. To dilute, use H_2O.

(*B*) Blue solution: 50 g $Ni(NH_4)_2(SO_4)_2.6H_2O$ + 10 g $(NH_4)_2SO_4$ + 55 cm³ NH_4OH (d = 0.90 g/cm³) + H_2O to make 1 l of solution at 20°C. To dilute, use aqueous solution of 10 g $(NH_4)_2SO_4$ per l of solution.

These solutions suitably diluted are used to equalize various color differences. The following transmission data refer to a flicker photometer using a 2° field and an effective brightness of 2.5 millilambert. Transmission measurements made with the usual Lummer-Brodhun field (about 8° by 15°) give a somewhat higher transmission for the blue, and lower for the yellow solution.

For the light from a standard 4 watt-per-candle carbon filament lamp (color temperature about 2077°K), the transmission of the diluted yellow solution is given by $\log_{10} T = -0.245C^{0.9}$, and of the blue by $\log_{10} T = -0.539C^{1.03}$, where C = concentration = number of cm³ of stock solution (A or B) per cm³ of the diluted solution, and T = relative transmission of 1 cm of solution at 20°C = τ_s/τ_w, where τ_w = transmission of a 1-cm cell having colorless glass walls and filled with clear H_2O at 20°C, and τ_s = transmission of same cell filled with the diluted solution at 20°C. Transmission = L_2/L_1 where $L_1[L_2]$ = light incident upon front [leaving rear] face of cell.

For the light from a source with a spectral distribution of light like that of a black-body at a temperature >2077°K the transmission of the yellow solution, when adjusted to give a color match with the 4 watt-per-candle carbon lamp, is given by $\log_{10} T = -0.366C^{1.05}$; *see* (1, 2, 3, 8).

Filters for Testing Observers.—For a normal or average observer using a flicker photometer under standard conditions and the light from a 4-watt-per-candle lamp, the two following aqueous solutions have equal transmissions at 20°C when contained in 1-cm cells of colorless glass. Yellow solution: 72 g $K_2Cr_2O_7$ to 1 l solution at 20°C. Blue solution: 57 g $CuSO_4.5H_2O$ to 1 l solution at 20°C; *see* (2, 4, 6, 7).

Filters for Physical Photometers.—Any receiver which responds to radiant energy in a definite and quantitative manner can be used as a photometer if covered by such a filter that the resultant spectral sensitivity curve is like that of the eye. All such known receivers which are accurately reproducible are non-selective, and for such the best filter appears to be a 1-cm thickness of the following solution, supplemented by clear H_2O sufficient to absorb practically all the infra-red (about 2 cm): 61.25 g $CuCl_2.2H_2O$ + 14.5 g $Co(NH_4)_2(SO_4)_2.6H_2O$ + 1.9 g K_2CrO_4 + H_2O to make 1 l; *see* (4, 6).

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MECHANICAL EQUIVALENT OF LIGHT

HERBERT E. IVES

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DEFINITIONS[1] AND SYMBOLS

1. *The efficiency of a source* is the ratio of the total luminous flux to the total power consumed (A. E. S. C. 46)(E_s).

2. The *luminous efficiency of the radiation* from any source is the ratio of the luminous flux to the radiant flux from the source (A. E. S. C. 22)(E).

3. The *visibility factor for the radiation* of a particular wave-length is the ratio of the luminous flux at that wave-length to the corresponding radiant flux (A. E. S. C. 18)(V_λ). (It is the luminous efficiency of monochromatic radiation of that wave-length.)

4. The *relative luminous efficiency of a source* or a *radiation* is the ratio of its efficiency to that of monochromatic radiation of maximum efficiency (about $\lambda = 0.555\mu$)(E_{sr}, E_r).

5. The *relative visibility factor* for a particular wave-length is the ratio of the visibility factor for that wave-length to the maximum value of the visibility factor (A. E. S. C. 19)($V_{\lambda r}$). (It is the relative luminous efficiency of monochromatic radiation of that wave-length.)

6. *Mechanical equivalent of the light* of a given radiation = power radiated per unit of luminous flux emitted = reciprocal of the luminous efficiency of the radiation.

7. *Least mechanical equivalent of light* = mechanical equivalent of monochromatic radiation of greatest luminous efficiency (about $\lambda = 0.555\mu$)(m).

If L = total luminous flux, R = total radiant flux, $L = \int_0^\infty L_\lambda d\lambda = \int_0^\infty V_\lambda R_\lambda d\lambda$, $R = \int_0^\infty R_\lambda d\lambda$, $E = L/R$, $E_r = E/(E_\lambda)_{max.} = E/(V_\lambda)_{max.} = mE$.

The value found for L, and hence for m, depends to some extent upon the conditions of observation (intensity of illumination, size of field, type of photometer, etc.). As there is no general agreement regarding what these conditions should be, the following data have a tentative character and those obtained by different observers are not always comparable.

TABLE 1.—RELATIVE VISIBILITY FACTOR ($V_{\lambda r}$) OF MONOCHROMATIC RADIATION (7)

These values, applying to photometric fields of relatively high brightness, have been tentatively adopted by the International Commission on Illumination. They are accurately represented by the formula: $V_{\lambda r} = 0.9896(R_1 e^{1-R_1})^{200} + 0.0820(R_2 e^{1-R_2})^{550} + 0.0650(R_3 e^{1-R_3})^{2000} + 0.0375(R_4 e^{1-R_4})^{630}$, where the R's are pure numbers defined by the equations $\lambda = \frac{0.555}{R_1}\mu = \frac{0.607}{R_2}\mu = \frac{0.523}{R_3}\mu = \frac{0.467}{R_4}\mu$; λ is the wave-length of the radiation considered. Mechanical equivalent $= m/V_{\lambda r}$, m = the least mechanical equivalent of light = 0.00161 watt/lumen; luminous efficiency of the radiation $= V_{\lambda r}/m$. Unit of $\lambda = 0.001\mu = 10$ Å; of $V_{\lambda r} = 1\%$, *see* Fig. 1; *see also* (2, 9, 11, 18, 19, 20).

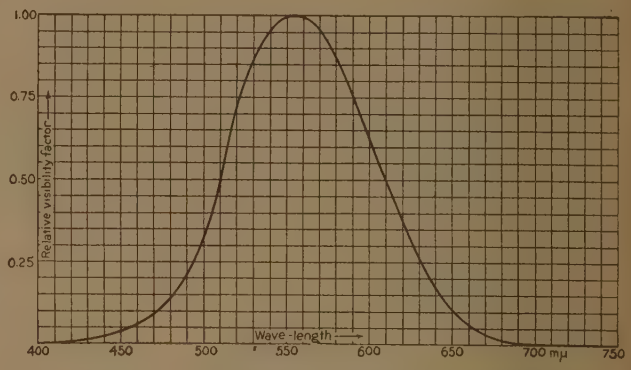

FIG. 1.—Relative visibility factor of monochromatic radiation (7.) Relative visibility factor = relative luminous efficiency. $1m\mu = 10^{-7}$ cm = 10 Å. (*See* Table 1.)

λ	$V_{\lambda r}$	λ	$V_{\lambda r}$	λ	$V_{\lambda r}$
400	0.04	530	86.2	660	6.1
410	0.12	540	95.4	670	3.2
420	0.40	550	99.5	680	1.7
430	1.16	560	99.5	690	0.82
440	2.3	570	95.2	700	0.41
450	3.8	580	87.0	710	0.21
460	6.0	590	75.7	720	0.105
470	9.1	600	63.1	730	0.052
480	13.9	610	50.3	740	0.025
490	20.8	620	38.1	750	0.012
500	32.3	630	26.5	760	0.006
510	50.3	640	17.5		
520	71.0	650	10.7		

TABLE 2.—LEAST MECHANICAL EQUIVALENT OF LIGHT

Value for green Hg-line, $\lambda = 5461$ Å, was derived from direct radiometric and photometric measurements; that for black-body (B. B.), from photometric measurements and computation of total radiation, using indicated values of σ and C_2; that for carbon lamp (C. L.), from measurement with and without a luminous efficiency screen. In column $V_{\lambda r}$ is indicated the relative visibility factor used in the reduction; $m_0[m]$ = value of the least mechanical equivalent as reported by observer (as corrected to basis of Table 1, $\sigma = 5.709 \times 10^{-12}$ watt cm^{-2} deg^{-4}, and $C_2 = 14\,330$ micron degree). The value found for m depends to some extent upon the conditions of observation (illumination, size of field, type of photometer), and there is no general agreement regarding what these conditions should be. Unit of $\sigma = 10^{-12}$ watt cm^{-2} deg^{-4}; of C_2 = micron degree; of m_0 and $m = 0.001$ watt lumen^{-1}.

Source	T, °K	σ	C_2	$V_{\lambda r}$	m_0	m	Lit.
5461 Å	(Assumed to be λ of max. efficiency)				1.44	1.42	(1)
5461 Å and C. L.				I (11)	1.59	1.61	(14, 15)

[1] The definitions, that are followed by the letters A. E. S. C. and a number, are those given by the American Engineering Standards Committee, and follow closely those adopted by the International Illumination Commission. The remaining quantities are not defined by those bodies, and it has accordingly been necessary to complete the list by definitions so worded as to be consistent with those adopted. Various authorities differ in terminology, and the definitions here given are not those elsewhere used and advocated by the writer.

TABLE 2.—(*Continued*)

Source	T, °K	σ	C_2	$V_{\lambda r}$	m_0	m	Lit.
5461 Å	(Observations of (14, 15)			C. E. (2)	1.61	1.61	(3)
B. B.		5.7	14 350	H. F. C. (9)	1.50		(9)
B. B.		5.7	14 350	C. E. (2)	1.65*		(3)
B. B.	1 336(Au)	†	14 300	I (11)	1.68		(8)
B. B.	1 336(Au)	†	14 350	I (11)	1.59	1.62	(8)
B. B.	2 035(Pt)	5.7	14 330	G. T. (7)	1.61	1.61	(13)
	Recommended value					1.61	

* Recomputation of observations (9); here corrected to agree with their later values (10). † $C_1 = 3.704 \times 10^{-12}$ watt cm².

TABLE 3.—LUMINOUS CHARACTERISTICS OF A BLACK-BODY

The relative luminous efficiency (E_r) of the radiation from the black-body is computed on the bases of Table 1 and the radiation constants ($\sigma = 5.709 \times 10^{-12}$ watt cm^{-2} deg^{-4}, $C_2 = 14\,330$ micron deg) chosen for I. C. T. (*cf.* (17)). $E_r = \left(\int_0^\infty V_\lambda J_\lambda d\lambda\right) \div \left(\int_0^\infty J_\lambda d\lambda\right)$; J_λ = monochromatic intensity of the radiation. B = brightness if least mechanical equivalent = 0.00161 watt lumen^{-1}; $B = b \times 10^n$; $E_r = e \times 10^{n'}$. Unit of B = 1 candle cm^{-2}.

T, °K	E_r		B*	
	e	n'	b	n
1 200	6.02	−6	1.41	−2
1 400	5.57	−5	2.42	−1
1 600	2.82	−4	2.08	0
1 700	5.41	−4	5.10	0
1 750	7.26	−4	7.69	0
1 800	9.57	−4	1.13	+1
1 850	1.24	−3	1.64	1
1 900	1.58	−3	2.32	1
1 950	1.98	−3	3.23	1
2 000	2.46	−3	4.44	1
2 050	3.01	−3	5.96	1
2 100	3.64	−3	7.98	1
2 150	4.36	−3	1.05	2
2 200	5.17	−3	1.37	2
2 250	6.06	−3	1.75	2
2 300	7.06	−3	2.23	2
2 350	8.16	−3	2.81	2
2 400	9.35	−3	3.50	2
2 450	1.07	−2	4.33	2
2 500	1.20	−2	5.31	2
2 550	1.35	−2	6.45	2
2 600	1.51	−2	7.80	2
2 650	1.68	−2	9.34	2
3 000	3.09	−2	2.83	3
4 000	8.07	−2	2.33	4
5 000	1.190	−1	8.40	4
6 000	1.353	−1	1.98	5
7 000	1.352	−1	3.67	5
8 000	1.258	−1	5.82	5
10 000	9.87	−2	1.115	6

* Between T = 1700 and 2650°K these values agree satisfactorily with observations of (6, 10), as recomputed to basis C_2 = 14 330 but are a little greater; greatest difference is 1.2 %.

TABLE 4.—LUMINOUS EFFICIENCY OF RADIATION FROM ELECTRICALLY EXCITED GASES AND VAPORS (4); *cf.* (5)

E = luminous efficiency; E_r = relative luminous efficiency; color = color of light emitted; p = probably. Unit of E = 1 lumen/watt; of E_r = 1 %.

Gas	Color	E	E_r
A	Red	0.24	0.04
As		0	0
Br	Blue-white	0.06	0.01
Cd	Blue-white	1.6	0.26
Cl	Blue	0.08	0.01
Cs	Blue-white	<0.4	<0.06
F		0.1p	0.02p
H	Red	0.08	0.01
He	White	4.4	0.71
Hg	Blue-green*	11	1.82
Hg	Blue-white†	126	20.3
I	White	1.1	0.18
K	Purple	1.8	0.28
Kr	Violet	<0.6p	<0.1p
Li	Red	‡	
N	Yellow-orange	1.6	0.26
Na	Yellow	214	34
Ne	Red-orange	23.0	3.6
O	Blue-white	0.05	0.01
P	Blue-white	§	
Rb	Red	0.24	0.04
S	Blue-white	0.89	0.14
Se		0p	0p
Tl	Green-white	0.08	0.01
Xe	Blue-green	<1p	<0.20p
Zn		0.13	0.02

* Without condenser. † With 0.14 microfarad condenser in parallel with tube. ‡ Vapor pressure too low for continuous discharge. § Too low to measure.

TABLE 5.—RELATIVE LUMINOUS EFFICIENCY (E_r) OF RADIATION FROM COMMERCIAL ILLUMINANTS (16)

Unit of E_r = 1 %

Source	Description	E_r
Incandescent electric lamps:		
Carbon, point source	4 w.p.c., 99 volt	0.45
Tungsten, vacuum	9.16 volt, 1.25 w.p.c.	1.65
Tungsten, vacuum	97.0 volt, 1.1 w.p.c.	1.84
Tungsten, vacuum	102.6 volt, 1 w.p.c.	1.99
Tungsten, nitrogen	6.6 amp., 0.65 w.p.c.	2.93
Mercury arc	1.7 amp., Pfund type	30.5
Nernst glower	0.8 amp., stereopticon type	1.08
Gas lamps:		
Incandescent mantle	0.25 % ceria	0.5
Incandescent mantle	0.25 % ceria	0.7
Incandescent mantle	0.75 % CeO_2, solid chimney	1.2
Incandescent mantle	0.75 % CeO_2, perforated chimney	1.26
Incandescent mantle	2 % ceria	0.8
Open burner		0.19
Standard candle	Sperm	0.24

TABLE 6.—EFFICIENCIES OF COMMERCIAL ILLUMINANTS (12)

Rating = commercial rating of lamp; E_s = luminous efficiency of lamp; E_{sr} = relative luminous efficiency of lamp = mE_s, m = least mechanical equivalent of light; w.p.c. = watts per mean horizontal candlepower; cp. = candlepower; amp. = ampere; D.C. [A.C.] = direct [alternating] current; BTU = British thermal unit; h.p.[l.p.] = high [low] pressure; 60 ~ = 60 cycles per second. Unit of E_s = 1 lumen per watt consumed; of E_{sr} = 1 %.

Lamp	Rating	E_s	E_{sr}
Incandescent electric:			
Carbon	4 w.p.c.	2.6	0.42
Treated carbon*	1.25 w.p.c.	8	1.3
Tungsten, vacuum	600 cp., 20 amp., 0.5 w.p.c.	19.6	3.2

TABLE 6.—(*Continued*)

Lamp	Rating	E_s	E_{sr}
Incandescent electric (*Cont'd*)			
Tungsten, Mazda-C	500 watt, multiple, 7 w.p.c.	15	2.4
Electric arc:			
Carbon, open	9.6 amp., clear globe	11.8	1.9
Carbon, enclosed†	6.6 amp., D.C.	5.9	0.96
Carbon, enclosed†	7.5 amp., A.C.	5.6	0.91
Magnetite	6.6 amp., D.C.	21.6	3.5
Mercury in glass	40 to 70 volt, 3.5 amp.	23	3.7
Mercury in quartz	147 to 197 volt, 4.2 amp.	42	6.8
Flaming,‡ enclosed:			
White, carbon	10 amp., A.C.	26.7	4.3
White, carbon	6.5 amp., D.C.	35.5	5.8
Yellow, carbon	10 amp., A.C.	31.4	5.1
Yellow, carbon	6.5 amp., D.C.	34.2	5.5
Flaming,‡ open:			
White, inclined	10 amp., A.C.	29	4.7
White, inclined	10 amp., D.C.	27.7	4.5
Yellow inclined	10 amp., A.C.	41.5	6.7
Yellow, inclined	10 amp., D.C.	44.7	7.2
Moore nitrogen tube	220 volt, 60~, 113.17 ft.	5.21	0.85
Nernst lamp		4.8	0.77
Gas lamps:			
Acetylene	1.0 liter per hr	0.67	0.11
Incandescent, l.p	0.350 lumen per BTU hr^{-1}	1.2	0.19
Incandescent, h.p	0.578 lumen per BTU hr^{-1}	2.0	0.32
Open flame	Bray 6 in., h.p.	0.22	0.036
Petroleum lamp		0.26	0.04

* Oval, anchored filament.

† Inner, light opal; outer, clear; lamp provided with street reflector. A resistance is in series with the A.C. arc.

‡ Ornamental type of lamp, clear globe, standard electrodes, series resistance.

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(For a key to the periodicals see end of volume)

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THE PROPERTIES OF PHOTOGRAPHIC MATERIALS

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The silver reduction equivalent of photographic developers.
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Part I

The Photochemical Equivalent of the Silver Halides [10]; *cf.* [9, 38, 41, 42, 43]

$\Sigma h\nu$ = sum of quanta absorbed per cm², N_{Ag} = number of silver atoms produced per cm² without development, $N/\Sigma h\nu$ = photochemical equivalent.

Fast plate				Process plate			
$10^{-16} \times \Sigma h\nu$	$N/\Sigma h\nu$	$10^{-16} \times \Sigma h\nu$	$N/\Sigma h\nu$	$10^{-16} \times \Sigma h\nu$	$N/\Sigma h\nu$	$10^{-16} \times \Sigma h\nu$	$N/\Sigma h\nu$
0.39	0.88	3.00	0.92	0.85	0.82	5.50	0.79
0.41	0.88	6.00	0.79	0.95	0.88	6.40	0.78
0.68	0.93	8.00	0.71	1.80	1.08	9.20	0.73
0.90	1.01	8.80	0.67	2.80	1.06	11.40	0.62
0.99	0.92	9.30	0.68	3.40	0.83	22.50	0.38
1.76	0.99	13.00	0.50	4.70	0.76	30.00	0.33
2.30	0.98						

The Silver Reduction Equivalent of Photographic Developers

By silver reduction equivalent (E_{Ag}) is meant the *number of atoms of metallic silver reduced per molecule of developer oxidized.* Temperature = 20°C and Ag is added as excess AgBr except as otherwise indicated.

Grams developer	Grams alkali	Grams Na_2SO_3	Vol., cm³	Duration of experiment	E_{Ag}	Lit.
			1. Quinol			
1.4	K_2CO_3, 20	20	*ca.* 300	20 min	4.3	(1)
1.4	K_2CO_3, 20	20	*ca.* 300	20 min	5.0*	(2)
1.4	K_2CO_3, 20	20	*ca.* 300	30 min	4.3	(3)
1.4	K_2CO_3, 20	20	*ca.* 300	60 min	7.8	(3)
0.11	NaOH, 2.2	0	25	6 hr	6.4	(14)
0.11	NaOH, 2.2	0	25	6 hr	9.3†	(14)
0.11	NaOH, 2.2	0	25	18 da	7.8	(14)
0.055	NaOH, 2.2	0.063	25	18 da	7.8	(14)
0.055	NaOH, 2.2	0.63	25	18 da	8.9	(14)
0.055	NH_4OH, *aq.* 20‡	0	40	8 da	8.0§	(14)
0.055	NaOH, 2.2	0	25	15 hr	10.5‖	(14)
			2. Pyrogallol			
	NH_4OH	0			*ca.* 4¶	(18); *cf.* (37)
0.063	NaOH, 2.2	0	25	1 hr	3.2	(14)
0.063	NaOH, 2.2	0.315	25	1 hr	3.4	(14)
			3. Pyrocatechol			
0.055	NaOH, 2.2	0	25	2 hr or 21 da	4.5	(14)
0.055	NaOH, 2.2	0.315	25	21 da	5.9	(14)
1.4	K_2CO_3, 20	20	*ca.* 300	21 min	1.9	(1)
			4. *p*-Aminophenol			
1.4	K_2CO_3, 20	20	*ca.* 300	20 min	3.9	(1)
			5. *o*-Aminophenol			
1.4	K_2CO_3, 20	20	*ca.* 300	20 min	0.7	(1)
			6. Chlorquinol			
1.9	K_2CO_3, 20	20	150	1 hr	6.7	(3)
			7. Quinone			
0.054	NaOH, 2.2	0	25	1 hr	3.9	(14)
0.054	NaOH, 2.2	0.63	25	1 hr	4.9	(14)
			8. Hydroxylamine as $NH_2OH.HCl$			
0.70	NaOH, 25**		100	60 min	1.1	(34)
0.70	NaOH, 50**		100	60 min	0.98	(34)
0.70	NaOH, 12.5**		100	60 min	1.01	(34)
0.70	NaOH, 12.5**		100	60 min	1.00	(34)
0.044	NH_4OH			60 min	2.00††	(34)
			9. Hydrogen peroxide			
1.720	NaOH			60 min	1.00	(34)

* Excess AgBr added progressively.
† t = 95–100°.
‡ Sp. gr. 0.9.
§ Ag as $AgNO_3$, 1.7 g.
‖ Ag as excess Ag_2O.
¶ Ag as excess ammoniacal $AgNO_3$.
** cm³ of 1*N* NaOH.
†† Ag as ammoniacal Ag_2O.

It is clear that the so-called silver equivalent of a given developing agent varies with the other constituents of the developer, the temperature, duration of run, and the form and manner in which the silver is added. Gordon [3] found, further, that the equivalent varies markedly with the method of shaking. It is probable that none of the values represents an equilibrium system and all are therefore to be regarded as tentative. Lüppo-Cramer [24], believes all determinations on silver halides in absence of emulsifying substances to be without photographic significance.

Photographic Development Velocity Functions and Constants

The rate of development may be measured by the increase of *density*, D, at a single exposure with time of development, t, or more satisfactorily, and in closer relation to photographic theory and practice, by the increase of *gamma*, γ, (constant or development factor) with time, t.

The function for (γ, t) will be of the same form as for (D, t), provided the straight line portions of the characteristic curves (*q.v.*, p. 442) meet on the axis of exposures. If they converge to a point below the axis, as when soluble bromide is present, then if a is the depression of density at the convergence point (*cf.* [28]) the function for ($D + a$), t will be the same as for γ, t.

For some emulsions the convergence point is above the axis, in which case the function for γ, t should be compared with ($D - a$), t.

Forms of Development Velocity Equation

	Log form	Exponential form	First derivative	Lit.
1	$Kt = \log_e \frac{D_\infty}{D_\infty - D}$	$D = D_\infty(1 - e^{-Kt})$	$\frac{dD}{dt} = K(D_\infty - D)$	(37)
2	$K(t - t_0) = \log_e \frac{D_\infty}{D_\infty - D}$	$D = D_\infty(1 - e^{-K(t-t_0)})$	$\frac{dD}{dt} = K(D_\infty - D)$	(37)
3	$K(\log_e t - \log_e t_0) = \log_e \frac{D_\infty}{D_\infty - D}$	$D = D_\infty(1 - e^{-K \log_e t/t_0})$	$\frac{dD}{dt} = \frac{K}{t}(D_\infty - D) = Kt^{-1}(D_\infty - D)$	(28)
4	$\log_e K + b \log_e (t - t_0) = \log_e \log_e \frac{D_\infty}{D_\infty - D}$	$D = D_\infty(1 - e^{-K(t-t_0)^b})$	$\frac{dD}{dt} = Kbt^{b-1}(D_\infty - D)$	(44)
5	$Kt = \log_e \frac{p\xi}{p\xi - D} - \frac{d}{(d + h)(D_\infty - p\xi)} \log_e \frac{D_\infty}{D_\infty - D}$		$\frac{dD}{dt} = K\frac{b - aD}{h(D_\infty - D) + d}(D_\infty - D)$	(33)

K = velocity constant of development. t = time of development in any unit selected. t_0 = empirical correction for the induction period in development. D_∞ = theoretical silver image density at infinite development. D = measured silver image density at time, t. a, b, d, h = empirical constants. $p\xi = D_\infty$ as used in 1–4. In 5, D_∞ represents the mass (unknown) of the latent image.

Equation 1 holds only for simple iron oxalate development, and for pyrogallol-soda (fairly). Equation 2 is of much wider application but in many cases fails in the advanced stages of alkaline development. Equation 3 has been found generally satisfactory by Nietz [28] in his extensive experimental work. Equation 4 is equally satisfactory and sometimes holds over a wider range but is more difficult of application. Equation 5 is of theoretical significance as being based upon the conception of the reversibility of the development process; it contains too many undeterminable terms to be practically useful.

DEVELOPMENT VELOCITY CONSTANTS AND RELATED DATA FOR VARIOUS DEVELOPERS ON THE SAME EMULSION (28)

Each developer contained 50 g Na_2SO_3, 50 g Na_2CO_3 and 1.19 g KBr per liter. Developing agents marked with an asterisk were of high purity, and others, excepting only edinol, duratol and eikonogen, which were the commercial product, were of better than commercial quality. D_∞, t_0, K as previously defined. γ_∞ = theoretical plate contrast reached on infinite development.

Developing agents all at 0.05 molal concn.	Constants of Eq. 3			
	D_∞	γ_∞	t_0, min	K
Toluquinol	4.40	1.67	1.35	0.63
Diaminophenol + alkali*	4.2	1.40	0.6	0.60
p-Aminophenol*	4.2	1.84	1.0	0.44
p-Amino-*m*-cresol	4.0	1.33	1.24	0.72
Methyl-*p*-amino-*o*-cresol	4.0	1.26	0.33	0.60
Pyrogallol*	4.0	1.22	0.78	0.57
Chlorquinol*	4.0	1.82	1.3	0.52
Quinol*	3.8	1.26	1.80	0.95
Dibromquinol	3.8	1.27	0.80	0.80
p-Amino-*o*-cresol	3.8	1.27	0.87	0.70
Bromquinol	3.8	1.73	1.27	0.66
Eikonogen	3.8	1.43	1.7	0.47
Monomethyl-*p*-aminophenol*	3.6	1.50	0.70	0.58
Diaminophenol, no alkali	3.6	1.63	0.36	0.55
Pyrocatechol	3.6	1.68	0.60	0.52
Dichlorquinol	3.6	1.29	0.80	0.53
Edinol	3.6	1.22	1.9	0.46
Phenylhydrazine, no alkali	3.5		8.5	0.03
p-Dimethylaminophenol	3.2	1.18	0.75	0.61
Ferrous oxalate*	3.1	1.29	0.97	0.55
Benzyl-*p*-aminophenol (duratol)	2.4	0.98	2.27	0.34
p-Phenylenediamine	1.7	0.58	2.10	0.34

The Temperature Coefficient of Development

Sheppard and Mees (36) found that in the case of ferrous oxalate development the temperature-development velocity relation was represented quite accurately by the integrated form of the Van't Hoff reaction isochore: $\log K = -\frac{A}{T} + C$, where K = development velocity constant, A, C = experimentally determined characteristic constants, T = absolute temperature.

The temperature coefficient for any development process for which the above relation holds is given by:

$$\alpha_{10} = \frac{K_T + 10}{K_T}$$

Ferguson (11) has proposed and successfully applied to general alkaline development the formula

$$\log b = \frac{\log M - \log m}{\Delta t}$$

in which b = temp. coeff. for 1°C. M, m = time of development giving equal factors at the higher and lower temperatures, respectively. Δt = temp. difference in °C.

TEMPERATURE COEFFICIENT OF DEVELOPMENT

Developing agent	Plate or emulsion	α_{10}	Lit.
Ferrous oxalate	"A"	1.60	(37)
Ferrous oxalate	"B"	1.90	(37)
Ferrous oxalate	"C"	1.70	(37)
Hydroxylamine	"C"	2.00	(37)
Quinol	"B"	2.20	(37)
Quinol	"C"	2.80	(37)
Quinol (tabloid)		2.25	(40)
p-Aminophenol	"C"	1.50	(37)
Metol	"C"	1.25	(37)
Pyrocatechol	"B"	2.80	(37)
Glycine (tabloid)		2.3	(40)
Metol-quinol		1.9	(40)

TEMPERATURE COEFFICIENT.—(*Continued*)

Developing agent	Plate or emulsion	α_{10}	Lit.
Rytol (tabloid)		2.2	(40)
Rodinal (*p*-aminophenol)		1.9	(40)
Pyrogallol soda, no bromide		1.5	(40)
Pyrogallol soda with bromide		1.9	(40)
Pyrogallol soda, no bromide	Wratten Panchromatic	2.0	(20)
Pyrogallol soda, no bromide	Imperial Ordinary	1.71	(12)
Pyrogallol soda, no bromide	Wratten Instantaneous	1.68	(12)
Pyrogallol soda, no bromide	Ilford Empress	1.55	(12)
Pyrogallol soda, no bromide	Imperial Special Rapid	1.76	(12)
Pyrogallol soda, no bromide	Ilford Special Rapid	1.85	(12)
Pyrogallol soda, no bromide	Wellington Rapid Special	1.99	(12)
Pyrogallol soda, no bromide	Barnet Extra Rapid	2.01	(12)
Pyrogallol soda, no bromide	Monarch	1.9	(12)
Pyrogallol soda with 0.1% bromide*	Barnet Extra Rapid	2.01	(12)
Pyrogallol soda with 0.1% bromide*	Ilford Empress	2.09	(12)

* Ferguson's results (12) for bromided pyrogallol, only two of which are quoted for illustration, gave a temp.-coeff. of approximately 2 for all the plates tested, irrespective of the unbromided values. Bromide apparently stabilizes the temp.-coeff., eliminating the emulsion effect observed by Sheppard and Mees (37). Watkins records a like conclusion (40). The temp.-coeff. of a developer is in general independent of its dilution.

Suggested Watkins' Factors (40)

Multiplication of the time of first appearance of the image by the suggested factor should give a negative of average contrast; the factor may then be adjusted to fit the peculiar requirements of the individual worker. Where the factor is evenly divisible into 60, a divisor is given: $\frac{\text{Time of appearance in seconds}}{\text{Divisor}}$ = correct development time in minutes.

Except in the case of pyrogallol and amidol the factor is independent of the developer strength. Variation in alkali does not alter the factor.

For sky, snow, and water negatives use a somewhat smaller factor, *e.g.*, ⅔ normal. For negatives devoid of high lights calculate development time on the basis of ⅗ of time of appearance.

Developer	grams/fl. oz. developer		mg/ml developer		Factor (and divisor)
	Pyro	Bromide	Pyro	Bromide	
Pyrogallol with Na_2CO_3	1	0	2.16	0	18
	2	0	4.32	0	12 (div. 5)
	3	0	6.48	0	10 (div. 6)
	4	0	8.64	0	8
	5	0	10.80	0	6.5
Pyrogallol with Na_2CO_3	1	2.16	0.25	0.54	9
	2	4.32	0.5	1.08	5 (div. 12)
	3	6.48	0.75	1.62	4.5
	4	8.64	1	2.16	4 (div. 15)
	8	17.28	2	4.32	3.25
Adurol					5 (div. 12)
Kachin					10 (div. 6)
Pyrocatechol					10 (div. 6)
Pyrocatechol cristoid					30 (div. 2)
Quinol (minimum bromide)					5 (div. 12)

Developer	Factor (and divisor)
Quinol (maximum bromide)	4.5
Eikonogen	9
Metol (Elon)	30 (div. 2)
Glycine with Na_2CO_3	8
Glycine with K_2CO_3	12 (div. 5)
p-Aminophenol	16
Amidol (2 grains/fl. oz)	18
Rodinal	40
Ortol	10 (div. 6)
Diogen	12 (div. 5)
Edinol	20 (div. 3)
2, 4-Diaminophenol (dianol)	60 (div. 1)
Quinomet	30 (div. 2)
Metol-quinol*	14

* The factors of combination developers depend upon the proportion of the two constituents, and when they contain pyrogallol, no rule can be given for finding the factor when diluted. The use of potash as an alkali instead of soda seems, with most developers, to require factors from one-quarter to one-half longer.

Reduction Potentials of Developers

The reduction potentials of developers were originally defined electrochemically (4)[1] but it has been shown that stable potentials, corresponding to equilibrium mixtures of reducer/oxidation-products, are not obtainable for alkaline organic developers (35). Relative reduction potentials were defined by Sheppard by relation to the theoretical equilibrium in development, and an empirical method of determining them worked out (34).

The relative reduction potentials π_{Br} determined by the bromide-depression method of Sheppard as applied by Nietz (28) is defined by the equation

$$\pi_{Br} = kC_0$$

where C_0 is the concentration of KBr required to produce an initial depression in the intersection point of the Hurter and Driffield curves; k is a constant as yet undetermined.

Relative Reduction Potentials of Photographic Developers (28)

Developer	Mole/l	π_{Br}, hydroquinol = 1.0
Ferrous oxalate	0.10	0.3
p-Phenylenediamine hydrochloride	0.05	0.3
p-Phenylenediamine hydrochloride + alkali	0.05	0.4
Methyl-*p*-phenylenediamine hydrochloride	0.05	0.7
Quinol	0.05	1.0
p-Phenylglycine	0.05	1.6
Hydroxylamine hydrochloride	0.10	2.0
Toluquinol	0.05	2.2
Methyl-*p*-phenylenediamine hydrochloride + alkali	0.05	3.5
p-Aminophenol hydrochloride	0.05	6.0
Chlorquinol	0.05	7.0
p-Amino-*o*-cresol	0.05	7.0
p-Dimethylaminophenol sulfate	0.05	10.0
Pyrogallol	0.05	16.0
Monomethyl-*p*-aminophenol sulfate	0.05	20.0
Bromquinol	0.04	21.0
Methyl-*p*-amino-*o*-cresol	0.05	23.0
2, 4-Diaminophenol	0.05	30 to 40

The Photometric Constant of the Developed Silver Image

D = density of the image, m_{Ag} = grams of silver per dm², $P = m_{Ag}/D$ = photometric constant, E = exposure in mcs. (*see* "Sensitometric constants" *below*).

[1] *Cf.* Vol. VI, section by Conant.

Density Range with Ferrous Oxalate Development; *cf.* (7, 17, 37)

10^3P =	1.21	1.31	1.03	1.031	1.19*
D range	0.525–1.97	0.76–2.54	0.5–2.0	0.5–3.5	0.08–1.64
Lit.	(13)	(13)	(7)	(37)	(32)

* No specific developer mentioned. Scheffers found that quinol, pyrogallol, metol, ferrous oxalate, and glycine gave identical results in his solarization experiments. Scheffers' results indicate that the photometric constant of the developed solarized image progressively diminishes, due to smaller silver grains being formed.

Effect of Exposure (32)

$\text{Log}_{10} E$	D	P	$\text{Log}_{10} E$	D	P
$\bar{5}.15$	0.08	1.125	$\bar{0}.95$	1.52	1.184
$\bar{4}.55$	0.16	1.250	$\bar{0}.35$	1.64	1.195
$\bar{3}.95$	0.34	1.176	0.25	1.55	1.200
$\bar{3}.35$	0.54	1.295	0.85	1.50	1.133
$\bar{2}.75$	0.86	1.139	1.45	1.35	1.126
$\bar{2}.15$	1.01	1.248	2.05	1.23	1.089
$\bar{1}.55$	1.34	1.149	2.65	1.12	1.062

Meidinger (27), developing with metol, has found that P varies with the grain size of the emulsion, a conclusion in accord with Higson (15) and Nutting (29). Meidinger concludes that for a given density, other factors constant, P is independent of exposure and development time.

Effect of Grain Size (27)

E, relative	D, range	m_{Ag}, range	Number of observations	P, average
Fast plate, large grain emulsion				
1–25 600	0.76–2.55	1.45–4.63	11	1.82
Process plate, fairly fine grain emulsion				
1–32	0.26–4.20	0.26–3.8	6	1.0
Transparency plate, very small grain emulsion				
1–512	0.05–3.05	0.04–2.95	10	0.83

The "covering power" of silver grains is proportional to the reciprocal of the photometric constant and increases with decreasing grain size. Thus Meidinger (27) found that the covering powers of a given mass of silver in the developed images of fast, process and transparency plates stood in the ratio 5: 9.1: 10.5, a conclusion in qualitative agreement with Higson and Toy (16).

Part II

Sensitometric Constants of Type Plates and Films

The definition of the sensitometric constants usually employed for expressing the characteristics of photographic materials can best be accomplished by referring to Fig. 1 which shows typical characteristic curves.

Density (D).—The blackness, or light absorbing power of a photographic deposit is expressed in terms of density defined as follows: Let F_0 = the luminous flux incident upon the deposit; F_1 = the luminous flux transmitted by the deposit; O = opacity; D = density; T = transmission.

Then

$$T = \frac{F_1}{F_0}$$

$$O = \frac{1}{T} = \frac{F_0}{F_1}$$

$$D = \log_{10} O = \log_{10} \frac{1}{T} = \log_{10} \frac{F_0}{F_1}$$

Exposure (E).—$E = It$ (expressed in meter candle seconds, mcs.); I = the illumination (in meter candles, mc.) incident on the photographic material during exposure; t = exposure time (expressed in seconds, s).

Spectral Composition of Exposing Radiation.—The values of speed given in the following table were obtained by using a light

source approximately equivalent to noon sunlight in spectral composition. The unit of photographic intensity is defined as one visual candlepower of radiation equivalent in spectral composition to mean noon sunlight.

Gamma (γ).—γ = tangent of angle α which the straight line portion of the characteristic curve makes with the exposure axis.

Gamma Infinity (γ_∞).—γ_∞ is defined as the theoretical limiting value to which γ approaches as the development time is increased. The values of γ_∞ given in the table are computed by the formula (37).

$$\gamma_\infty = \frac{\gamma_1}{1 - e^{-Kt_1}}$$

where γ_1 is the slope of the straight portion for the development time t_1, and K is the velocity constant of development.

Velocity Constant of Development (K).—$K = \frac{1}{i}\log_e \frac{\gamma_1}{\gamma_2 - \gamma_1}$.

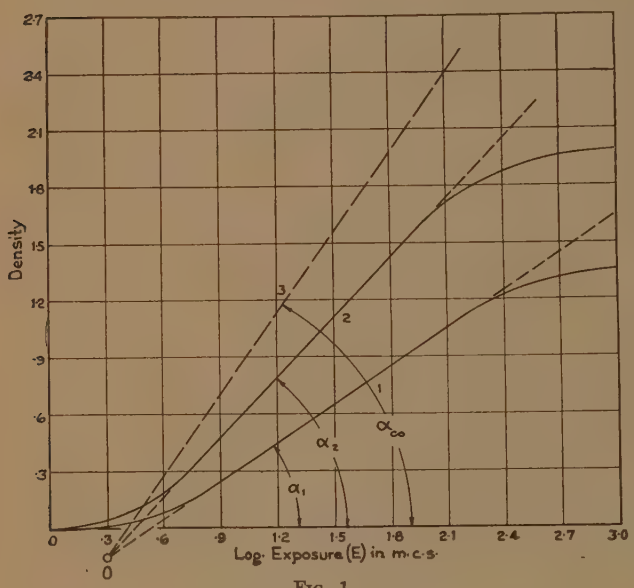

FIG. 1.

Time of Development for Gamma of Unity ($t_\gamma = 1.0$).—The rate of development for practical purposes may be indicated by the time of development required to give a gamma of unity. The values determined experimentally for the various type plates and with the developer made up according to the appended formula are given in the table of constants.

Fog (F).—Fog is defined as the density produced when the plate is developed without exposure. This value naturally depends upon the extent to which development is carried and the values given in the table are for a development time which would result in a gamma of unity.

Latitude (L).[1]—L = length of the projection (expressed in exposure units) of the straight line portion on the $\log_{10} E$ axis, assuming development to a gamma of unity.

Inertia (i).—i = the value of exposure where the straight line portion of the characteristic curve extended cuts the $\log_{10} E$ axis. The straight line portions of curves plotted for different development times in general intersect in a point 0 which may lie above, on, or below the $\log_{10}$ exposure axis. The value of i, therefore may depend upon the extent to which development is carried. The values of i given in the table were determined for a gamma of unity.

[1] Sometimes called Scale, *see* (5).

Speed (S).—$S = \frac{1}{i} \times 10$. Values in table do not include the factor of 10.

SENSITOMETRIC CONSTANTS FOR TYPE PHOTOGRAPHIC MATERIALS

Material	Fog $\gamma = 1$	K	γ_∞	t (for $\gamma = 1.00$)	L	i
1. Cine, Extra Fast	0.20	0.10	1.4	8.5	100	0.0083
2. Cine, Normal	0.15	0.14	1.3	8.5	64	0.014
3. Cine, Panchromatic	0.15	0.15	2.0	3.5	50	0.025
4. Cine, Positive	0.03	0.23	2.7	1.2	32	0.500
5. Portrait, Extra Fast	0.18	0.10	1.4	8.5	100	0.0083
6. Portrait, Normal	0.15	0.10	1.8	5.0	64	0.0166
7. Amateur Film	0.15	0.10	1.8	5.0	32	0.022
8. "Focal Plane" Plates	0.15	0.10	1.7	6.0	64	0.010
9. Commercial, Ordinary	0.05	0.10	2.2	3.0	32	0.050
10. Commercial, Orthochromatic	0.12	0.14	2.2	4.0	50	0.033
11. Commercial, Panchromatic	0.15	0.15	2.3	3.5	32	0.050
12. Process, Ordinary	0.03	0.18	3.0	1.5	16	0.250
13. Process, Panchromatic	0.10	0.12	3.0	2.0	16	0.143
14. Lantern Slide Plate	0.03	0.22	3.0	1.2	16	0.500

FORMULA FOR LABORATORY PYROGALLOL DEVELOPER

Solution A	g	Solution B	g
Na_2SO_3	70	Na_2CO_3, anhyd	75
$NaHSO_3$	17	KBr	1
Pyrogallol	20	Water to 1 liter	
Water to 1 liter			

Temperature 20°C. For use, mix equal volumes of A and B.

Spectral Sensitivity of Photographic Materials

The spectral distribution of sensitivity for practical purposes is shown qualitatively by means of wedge spectrograms. These are made by the use of a spectrograph over the slit of which is mounted a wedge of neutral gray glass, the transmission of which decreases logarithmically from the thin to the thick end. The wedge constant was 0.75/mm. In this way the exposure incident on the photographic material for any particular wave-length decreases logarithmically in a direction parallel to the slit of the instrument. When such an exposure is developed the silver deposit on the plate outlines approximately a curve which is the resultant of the *spectral sensitivity* function of the material and the *spectral distribution of energy* in the radiation emitted by the source used for illuminating the slit of the instrument.

The source used in making the spectrograms (Figs. 2 and 3) was the acetylene flame which operates at the color temperature of 2360°K. All plates were given the same exposure. Since the same source was used in all cases, the curves as outlined by the light areas show the *relative spectral sensitivity* of the various materials. By the application of a correction based upon the spectral distribution of energy radiated by a black-body at 2360°K, an approximation to the actual spectral sensitivity of these materials may be obtained. The neutral glass wedge used over the slit of the instrument while fairly non-selective in absorption for radiation of wave-lengths longer than 450 mμ, increases in density for radiation of wave-lengths shorter than 450 mμ. The apparent falling off in sensitivity in the region of wave-lengths shorter than 450 mμ is therefore due to excessive absorption of the neutral wedge rather than to a decrease in the spectral sensitivity of the material (26, 39).

Resolving Power, Sharpness, and Astro Gamma

Resolving Power

The capacity of the photographic plate or film to render fine detail is usually referred to as its resolving power (R). Resolving power is usually determined by photographing on the material a

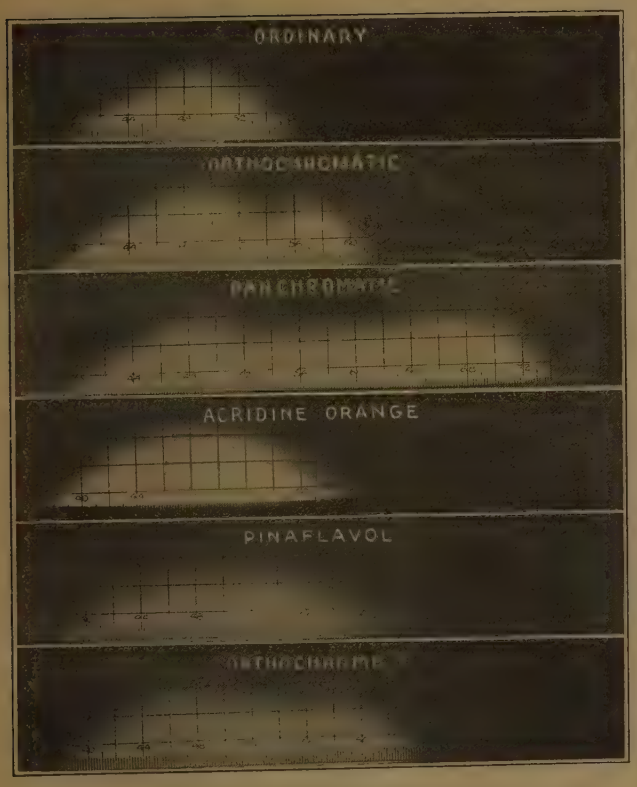

FIG. 2.

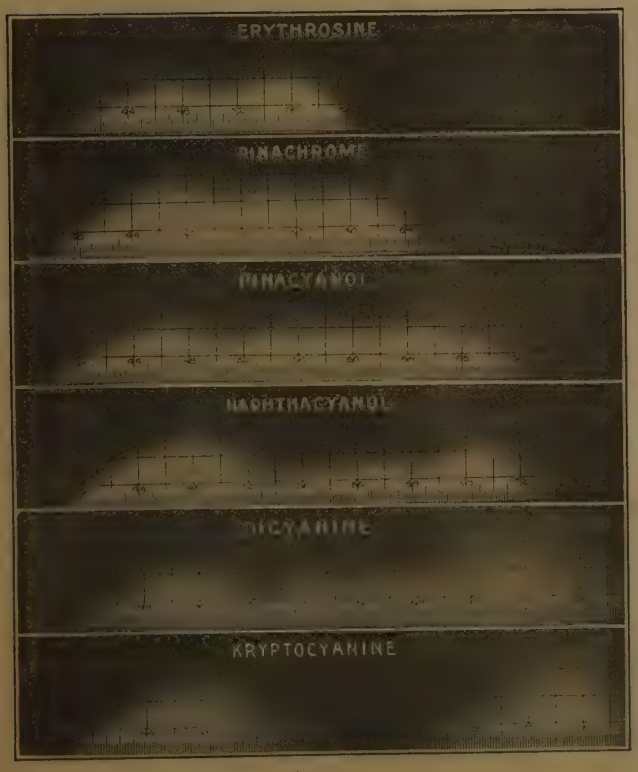

FIG. 3.

grating consisting of alternate light and dark lines, each line being of a width equivalent to the space between the consecutive lines. Resolving power is then specified by stating the number of lines per mm resolvable by the material. For detailed descriptions of methods, *v.* (25, 31).

In Table 1 are given the values of resolving power, as determined by the fan method (25), for a group of materials differing widely in sensitivity. Pyrogallol developer was used in all cases with the exception of the albumen plate, which was developed physically. The light source used in making the exposure was a gas-filled tungsten lamp operated at approximately 2800°K.

TABLE 1 (19)

Plate	Relative speed	Resolving power
Albumen	0.01	125
W and W Resolution	3.0	81
W and W Slow Process Pan	5.0	67
Seed Lantern (yellow label)	6.0	62
Positive Motion Picture Film	10.0	42
Seed 23	150.0	35
W and W Panchromatic	200.0	31
Seed 30	400.0	29
Seed Graflex	450.0	25

The resolving power of a photographic plate is dependent to a certain extent upon the reducing agent used in the developing solution. It is also dependent to a certain extent upon the length of time of development and upon exposure. For any given photographic material and developing solution there is a combination of development time and exposure which gives a maximum resolving power. Values of maximum resolving power, as determined by the fan method (25), for various developers are given in Table 2, the light source being a gas-filled tungsten lamp operated at 2800°K.

TABLE 2 (19)

Developer	Maximum resolving power	Exposure (in sec)	Development (in min)
Pyrogallol, NaOH	77.0	4	2
Glycine	69.0	3	1
Quinol	64.0	3	2
Pyrogallol, Na_2CO_3	64.0	3	2
Metol-quinol	64.0	3	2
Metol	63.0	3	2
Nepera	62.0	3	2
Pyrocatechol	62.0	8	2
Pyro-metol	62.0	8	2
Eikonogen-quinol	61.0	4	3
Ferrous oxalate	61.0	2	4
Caustic quinol	57.0	4	2
Eikonogen	57.0	4	4
Amidol	51.0	2	4
Kachin	54.0	2	5
Ortol	49.0	4	2
p-Aminophenol	49.0	8	2
Edinol	47.0	4	16

Curves showing the relation between *wave-length* and *resolving power* (fan method) for Seed 30 (S30), Seed 23 (S23), Seed Process (SP), and Wratten and Wainwright Process Panchromatic (WWPP) are shown in Fig. 4 (30, 31).

The increase in resolving power resulting from bathing the material in a solution of yellow dye prior to exposure is shown by the curves marked (YD). The ordinate values are in lines per mm (fan method) which can be resolved under the conditions specified.

Values of resolving power determined by using series of parallel lines may be more directly applicable for practical purposes

especially from the standpoint of spectroscopy. In Table 4 [6] are given values determined in this way for a series of typical photographic materials. The test object was illuminated by light of daylight quality. An image, at a magnification of 0.05, was projected on the surface of the photographic material by means of a highly corrected lens. The exposures were such that a development to gamma of unity in pyrogallol at 20°C gave the maximum resolving power.

Sharpness

The "sharpness" characteristic of a photographic material is defined as the differential of density (D) with respect to distance (s) in a direction perpendicular to the edge of the image; sharpness (S) = dD/ds, where s is expressed in microns (0.001 mm).

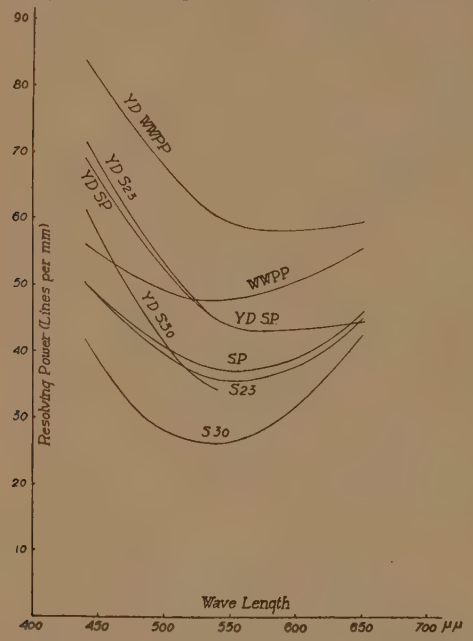

FIG. 4.

The images used for determination of sharpness are obtained by making a contact print of a very carefully prepared knife edge. The exposing radiation used in making the print is carefully collimated and incident normal to the surface of the material being examined.

The sharpness of the developed image depends upon the extent to which development is carried and this is specified by the value of gamma (γ), $\dfrac{dD}{d \log_{10} E}$.

The curves of Fig. 5 [30, 31] show the relation between sharpness and gamma for various developers. The plate used in obtaining these values was a Seed Panchromatic and the exposing radiation was monochromatic of wave-length 440mμ.

Sharpness is independent of exposure, at least over a considerable range, as shown in Table 3. The term "light exposure" is used to designate an exposure resulting in an image density of approximately 1.0, while the term "heavy exposure" is used to designate an exposure resulting in an image density between 2.0 and 3.0. The plate used was a Seed Panchromatic developed in caustic hydroquinol.

TABLE 3.—DENSITY GRADIENTS

	λ = 420mμ			λ = 520mμ			λ = 660mμ		
Development time, min.	0.75	1.5	3.0	0.75	1.5	3.0	0.75	1.5	3.0
For light exposure....	0.107	0.136	0.143	0.051	0.059	0.069	0.053	0.070	0.082
For heavy exposure...	0.112	0.133	0.151	0.045	0.061	0.063	0.056	0.064	0.086

The relation between sharpness and wave-length of the exposing radiation is shown in Figs. 6 and 7 [30, 31], the former applying to a panchromatic (Seed Panchromatic) and the latter to an orthochromatic (Standard Orthonon) material.

Values of sharpness for a group of typical materials are given in Table 4 [6]. The quality of light used in making the exposures was equivalent to average daylight. The exposure was so adjusted that development to gamma of unity in pyrogallol at

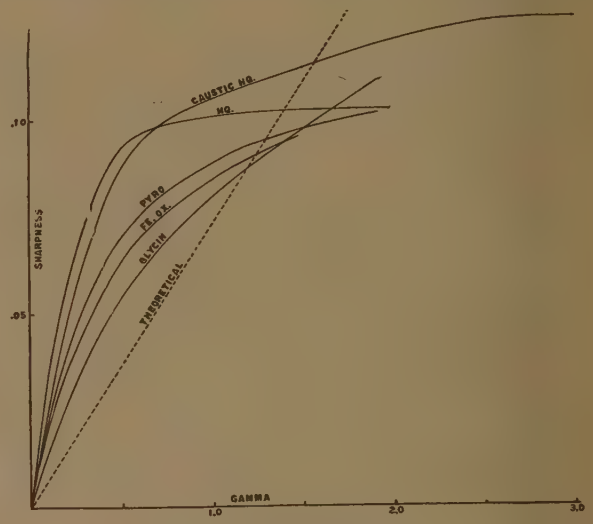

FIG. 5.

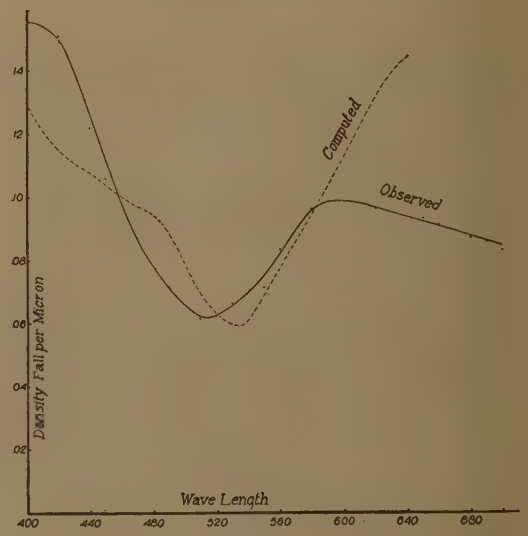

FIG. 6.

20°C gave an image density of unity. The values of sharpness express the diffuse-density gradient (dD/ds) of the straight line portion of the sharpness curve obtained by plotting diffuse-density (D) as a function of the distance (s) from the geometrical edge of the image.

Astro Gamma

Astro gamma is defined as the coefficient (b) of $\log_{10} E$ in the Scheiner equation, which gives the relation between the diameter (D) of a stellar image and the exposure (E): $D = a + b \log_{10} E$.

Since exposure (E) = intensity (I) × time (t) this equation offers a means of determining the relative brightness of stars by measurement of the diameter of the stellar images obtained under known conditions of exposure and development. The ordinate values used in plotting Fig. 8 are relative and must be multiplied by 3.33 ($1/\log_{10} 2$) in order to obtain actual values of astro gamma as defined above.

In Table 4 (6) are given values of astro gamma for a group of typical photographic materials. These values were determined by photographing with a highly corrected lens, using a magnification of 0.05, a circular aperture having a diameter of 0.56 mm. Exposing radiation was of daylight quality and intensity was so adjusted that an exposure of 1 second was just above the threshold value. Keeping the intensity factor constant, the exposure time was increased by consecutive powers of 2 from 1 to 512 seconds. The exposed plates were developed to a gamma of unity in standard pyrogallol at 20°C.

TABLE 4

Emulsion	Resolving power	Sharpness	Astro gamma
Eastman Lantern	140	0.168	39*
Eastman Process	140	0.156	30*
Eastman Cine Positive	120	0.103	26*
W and W Process Panchromatic	102	0.092	33
Eastman 33	95	0.088	32
Eastman D. C. Ortho	80	0.097	41
Eastman Universal	70	0.093	40
Eastman 40	70	0.071	49*
Eastman Speedway	60	0.080	44
Eastman Cine, Par Speed	60	0.085	35
Eastman Cine Superspeed	50	0.080	36
Eastman Superspeed Portrait	50	0.065	43

* The growth of the diameter with the log exposure deviates much from a linear relationship. The value given is the average of the values over the whole range of exposures.

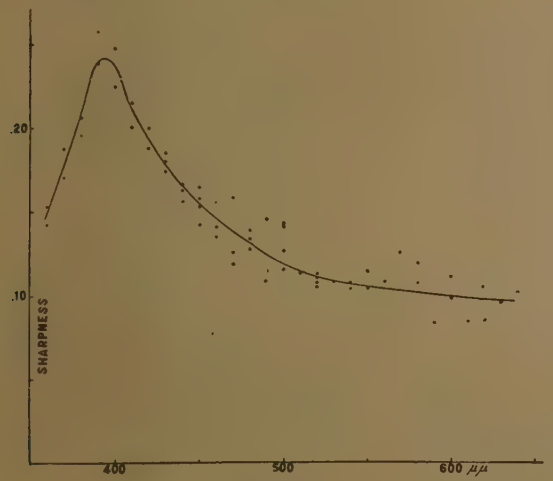

FIG. 7.

Relative Photographic Efficiency of Illuminants (23)

C = luminous efficiency of source (lumen/watt). E_r = relative photographic efficiency of source evaluated on basis of equal visual intensities, sunlight = 100%. E_e = relative photographic efficiency of source evaluated on basis of equal energy consumption by the source, sunlight = 100%.

Efficiency of Illuminants.—(*Continued*)

Source	C	Photographic material				Panchromatic	
		Ordinary		Orthochromatic			
		E_r	E_e	E_r	E_e	E_r	E_e
Sun	150	100	100	100	100	100	100
Sky		181		155		130	
Acetylene	0.7	30	0.14	44	0.21	52	0.24
Acetylene (screened)*	0.07	81	0.037	85	0.040	89	0.042
Pentane	0.45	18	0.053	28	0.086	42	0.13
Mercury arc in quartz	40.0	600	158	500	132	367	99
Mercury arc in nultra glass	35.0	218	50	195	46	165	39
Mercury arc in crown glass	37.0	324	79	275	68	249	62
Carbon arc, ordinary	12.0	126	10	112	9	104	8.5
Carbon arc, white flame	29.0	257	52	234	45	215	4.2
Carbon arc, enclosed	9.0	175	11	177	11	165	10
Carbon arc, "Aristo"	12.0	796	62	1070	86	744	60
Magnetite arc	18.0	106	12	115	14	82	10
Carbon glow lamp	2.4	23	0.37	32	0.52	42	0.68
Carbon glow lamp	3.2	25	0.51	35	0.74	45	0.95
Tungsten (vacuum)	8.0	33	1.7	41	2.2	50	2.7
Tungsten (vacuum)	9.9	37	2.4	45	3.0	53	3.5
Tungsten (gas filled)	16.6	56	6.1	62	6.8	70	7.7
Tungsten (gas filled)	21.6	64	8.9	68	9.8	76	11.0
Tungsten (C_3)	8.9	95	5.5	87	5.2	95	5.6
Tungsten (C_3)	11.0	108	7.8	99	7.3	106	7.9
Mercury vapor	23.0	316	47	354	54.2	273	42.0

* Screened with Wratten No. 79 filter.

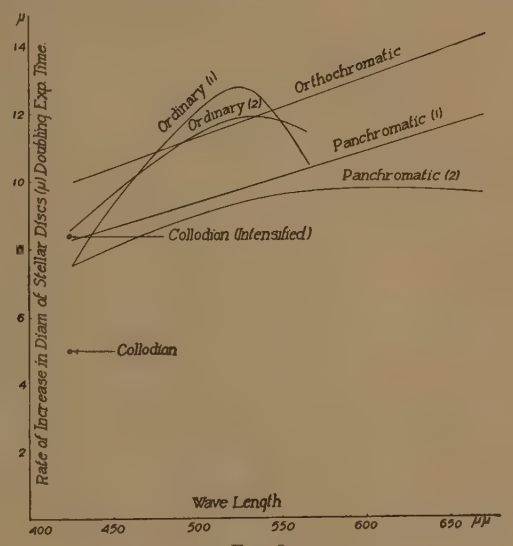

FIG. 8.

Gloss of Photographic Papers

Definition of Gloss.—With the surface illuminated by a collimated beam of light incident at 25° from the normal to the surface, B_s is the brightness of the sample as observed on the line of specular reflection (angle of observation equal to angle of incidence) and B_d is the brightness of the surface observed normally.

Specular brightness, $(B_s) = B_s - B_d$; diffuse brightness, $(B_d) = B_d$; gloss $(G) = \dfrac{B_s}{B_d} = \dfrac{B_s - B_d}{B_d} = \dfrac{B_s}{B_d} - 1$.

RANGE OF GLOSS VALUES

Matte	Semi-matte	Semi-gloss	Gloss
0–1	1–3	3–7	7–∞ *

* Actual limit = 75.

These values apply to samples which were fixed out without exposure and hence represent the white paper without any developed silver deposit (22).

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(For a key to the periodicals see end of volume)

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PROPERTIES OF SOAPS AND THEIR AQUEOUS SOLUTIONS

JAMES W. McBAIN

A soap is here defined as a salt of any monobasic aliphatic acid containing six or more carbon atoms. The substance cetylsulfonic acid is also classed as a soap.

Un savon est défini ici comme étant un sel de tout acide aliphatique monobasique contenant six atomes de carbone ou plus. La substance acide cétylsulfonique est aussi classée comme savon.

Die Seife ist hier definiert als ein Salz irgend einer aliphatischen einbasischen Säure, welche sechs oder mehr Kohlenstoffatome enthält. Der Stoff Cetylsulfonsäure ist als eine Seife klassifiziert.

Si intende qui per sapone il sale di un acido alifatico monobasico qualunque contenente sei o più atomi di carbonio. L'acido cetilsolfonico è considerato anch' esso un sapone.

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Symbols and Molecular Weights

N_w (resp. N_v) = Gram-moles per kg H_2O (resp. per l solution), % = weight per cent

Symbol	Name	Mol. wt.	Symbol	Name	Mol. wt.
NaC_6	Caproate or hexoate	138.082	KC_{18}	Stearate	322.365
KC_6		154.180	NaC_{22}	Behenate	362.328
NaC_8	Caprylate or octoate	166.113	$C_{16}SO_3H$	Cetylsulfonic or hexadecanesulfonic acid	306.327
KC_8		182.211	$C_{16}SO_3Na$	Cetylsulfonate	328.316
NaC_9	Nonylate	180.128	NaC_{18}^{-}*	Oleate	304.251
NaC_{10}	Caprate or decoate	194.143	KC_{18}^{-}*	Oleate	320.349
KC_{10}		210.241	$NH_4C_{18}^{-}$	Oleate	299.293
NaC_{12}	Laurate	222.174	$NaC_{18}^{=}$	Linolate	302.236
KC_{12}	Laurate	238.272	$KC_{18}^{=}$	Linolate	318.334
NaC_{14}	Myristate	250.205	NaC_{22}^{-}	Erucate	360.313
KC_{14}	Myristate	266.303	KC_{22}^{-}	Erucate	376.411
NaC_{16}	Palmitate	278.236	$NaC_{18}^{\equiv}$	Linolenate	300.22
KC_{16}	Palmitate	294.334	$KC_{18}^{\equiv}$	Linolenate	316.318
NH_4C_{16}	Palmitate	273.278	$NaC_{18}^{-}OH$	Ricinoleate	320.251
NaC_{18}	Stearate	306.267	$KC_{18}^{-}OH$	Ricinoleate	336.349

* The symbol C_{18}^{-} is used in the tables for oleates only, the stereoisomeric elaidates being named in full.

Conversion Formulae

$$\text{Wt. \%} = \frac{\text{Mol. wt.} \times N_w}{\text{Mol. wt.} \times N_w + 1000} \times 100$$

$$N_w = \frac{\text{Wt. \%}}{\text{Mol. wt.}} \times \frac{1000}{100 - \text{Wt. \%}}$$

$$N_v = \frac{\text{Wt. \%} \times \text{density of solution} \times 10}{\text{Mol. wt.}}$$

Equilibria within Soap Solutions

The diagrams, Figs. 1–19, represent the proportions of the various constituents in equilibrium with each other in the soap solutions. They are obtained primarily from a comparison of conductivity and osmotic data but some of the results are confirmed by measurements of Na and K ion by emf, ultrafiltration, etc. In each concentration the sum total of constituents containing fatty acid radical is taken as 100 % (the total height of the diagram) which is the sum of the following: Colloidal neutral undissociated soap, crystalloidal undissociated soap, fatty ion and fatty ion aggregated as ionic micelle; in addition there is free Na or K ion equal in amount to the number of equivalents of free fatty ion plus the fatty ion in ionic micelle. To read off the actual concentration of any one constituent at a given concentration the width of the field representing that constituent must be multiplied by the total concentration of the solution. The uncertainty in the position of the boundaries between fields is estimated as about 10 % of the total amount of soap. For further description, *see* (89). Constituents of a soap solution containing added salt (109).

Symbols

N Neutral colloid, *e.g.*, $(KC_{18})_x$.
S Simple soap molecules, *e.g.*, KC_{18}.
S′ Simple fatty ions, *e.g.*, C^-_{18}.
A Acid soap.
M Ionic micelle, *e.g.* $(C^-_{18})_n$.

Viscosity

Values of η in poises

Solutions of Pure Soaps. *See* Figs. 20, 21, and 22

Capillary viscometer with absolute dimensions such that kinetic correction did not exceed 1 %. Viscosity compared with that of water at 20° taken as unity (51).

Soap	N_v at 90°	20°	30°	45°	60°	90°
KC_{12}	0.1	1.15		0.671	0.532	0.352
	0.2	1.41	1.13	0.846	0.661	0.434
	0.375	1.96		1.16	0.906	0.604
	0.4	2.08	1.65	1.24	0.962	0.626
	0.6	3.28	2.61	1.97	1.54	1.03
	0.8	4.97	4.01	3.04	2.37	1.55
	1.0	8.42	6.94	5.38	4.24	2.81
KC_{14}	0.054	1.14	0.895	0.672	0.519	0.346
	0.216	1.70	1.32	0.983	0.752	0.497
	0.431	2.83	2.17	1.63	1.25	0.825
	0.649	4.94	3.84	2.87	2.22	1.45
	0.815	9.34	7.67	5.86	4.56	2.85
	1.035	39.1	36.2	28.3	17.7	6.47
KC^-_{18}	0.052	1.19	0.95	0.709	0.545	0.364
	0.2	1.87	1.47	1.10	0.837	0.500
	0.375	4.19		1.91	1.39	0.919
	0.4	8.02	4.69	3.12	1.99	1.13
	0.6	1573		60.22	18.03	3.80

See further the following references: NaC_{16}, KC_{16} (3, 99), KC^-_{18} (11), NaC_{18} (99), NaC^-_{18} (99), $NH_4C^-_{18}$ (2, 33, 34, 35), Na salt of fatty acids from tallow and from coconut oil (99). K and NH_4 salts of fatty acids from palm kernel oil (27, 28, 51).

Viscosity of Soap Solutions with Additions of Other Solutes

Bibliography only

Soap	Addition	Lit.
KC_{12}	KOH	(51)
KC_{12}	KC^-_{18}(I + KOH)	(51)
KC^-_{18}	KOH	(51)
K (palm)*	KOH	(27)
	KCl	
K (palm)*	Glycerol	(28)
	Acetone	
K (palm)*	K_2CO_3	(51)
	KOH	
K (coco)†	KCl	(56)
	KC_{18}	
NaC_{12}	NaOH	(108)
NaC_{16}	NaCl	(44, 91)
	Na_2CO_3	
	$NaC_2H_3O_2$	
	NaOH	
	NaCl	(22)
	KCl	
NH_4 (palm)*	NH_3	(28)
	NH_4Cl	
	Both	

* Palm kernel oil acids. † Coconut oil acids.

Density (Specific Gravity)

$d^t_4 = A + kN_w$; Values of d^{18}_4; A = 0.9986 = d^{18}_4 of H_2O

Soap	$0.05N_w$	$0.1N_w$	$0.2N_w$	$0.5N_w$	$1.0N_w$	k	Lit.
NaC_8*	1.003	1.004	1.008	1.016	1.030	†	(54)
NaC_{12}*	1.001	1.002	1.004			†	(54)
NaC^-_{18}	0.9990	0.9995	1.0005	1.0035		+0.0098	(53, 77)
KC^-_{18}	0.9992	0.9998	1.0010	1.0047		+0.0122	(77)
K elaidate	0.9990	0.9994	1.0001	1.0024		+0.0076	(90)
$NaC^{=\!=\!=}_{18}$	0.9993	1.0001	1.0016	1.0060		+0.0148	(84)
$NaC^-_{18}OH$	1.000	1.0013	1.0038	1.0097	1.017	†	(71)

* Volume normality (N_v) and d^{18}_{18}. † Not linear.

Values of d^{90}_4; A = 0.9653 = d^{90}_4 of H_2O

Soap	$0.2N_w$	$0.5N_w$	$1.0N_w$	k	Lit.
KC_8	0.972	0.982	0.998	+0.033	(16)
KC_8	0.9702	0.9777	0.9902	+0.0249	(16)
NaC_9	0.9690	0.9744	0.9833	+0.0180	(26)
KC_{10}	0.9689	0.9743	0.9833	+0.0180	(16)
NaC_{12}	0.9668	0.9692	0.9731	+0.0029	(70)
KC_{12}	0.9676	0.9712	0.9770	+0.0117	(16)
NaC_{14}	0.9658	0.9665	0.9678	−0.0025	(70)
KC_{14}	0.9667	0.9688	0.9723	+0.0070	(16)
NaC_{16}	0.9647	0.9639	0.9624	−0.0029	(18)
KC_{16}	0.9659	0.9667	0.9680	+0.0027	(16)
NaC_{18}	0.9631	0.9599		−0.0108	(18)
KC_{18}	0.9650	0.9645	0.9637	−0.0016	(16)
NaC_{22}	0.96312	0.96		−0.011	(26)
$C_{16}SO_3H$	0.9637	0.9613		−0.0080	(100)

For the K salt of palm-kernel oil (also with added KOH) at 20°, 60°, and 90°, *v.* (27). For the NH_4 salt of palm-kernel oil at 20°, 45°, and 60°, *v.* (28).

Values of d^t_4 for $0.1N_v$ Solutions (3)

	35°	45°	55°	65°	75°	85°
NaC_{16}			0.986	0.981	0.974	0.968
KC_{16}	0.994	0.991	0.987	0.982	0.975	0.969

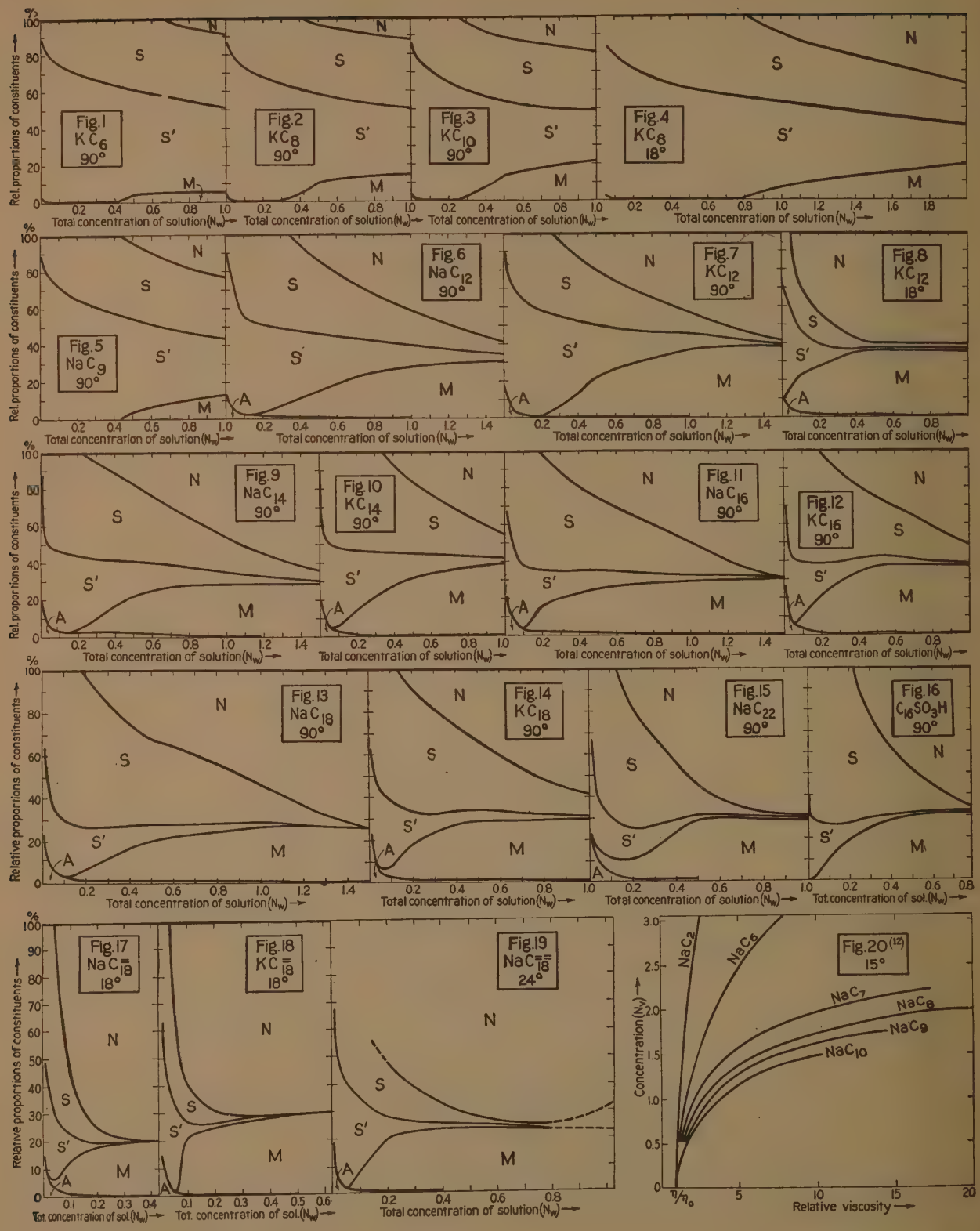


Fig.1 KC6 90°
Fig.2 KC8 90°
Fig.3 KC10 90°
Fig.4 KC8 18°
Fig.5 NaC9 90°
Fig.6 NaC12 90°
Fig.7 KC12 90°
Fig.8 KC12 18°
Fig.9 NaC14 90°
Fig.10 KC14 90°
Fig.11 NaC16 90°
Fig.12 KC16 90°
Fig.13 NaC18 90°
Fig.14 KC18 90°
Fig.15 NaC22 90°
Fig.16 C16SO3H 90°
Fig.17 NaC18 18°
Fig.18 KC18 18°
Fig.19 NaC18 24°
Fig.20[12] 15°
Rel. proportions of constituents
Relative proportions of constituents
Total concentration of solution (Nw)
Tot. concentration of sol. (Nw)
Concentration (Nw)
Relative viscosity
η/η0
NaC2
NaC6
NaC7
NaC8
NaC9
NaC10
N
S
S'
M
A

VALUES OF d_4^t FOR NaC_{18}^-

For the anhydrous soap, $d_4^{20} = 0.821$ (101)

N_v \ t, °C	16 (54)	20 (32)	N_v \ t, °C	0 (53)	10 (53)
0.005	1.001*	0.9983	0.2	1.0012	1.0005
0.01	1.001*	0.9984	0.4	1.0040	1.0029
0.1	1.003*	0.9989	0.6	1.0068	1.0062
0.2	1.004*				

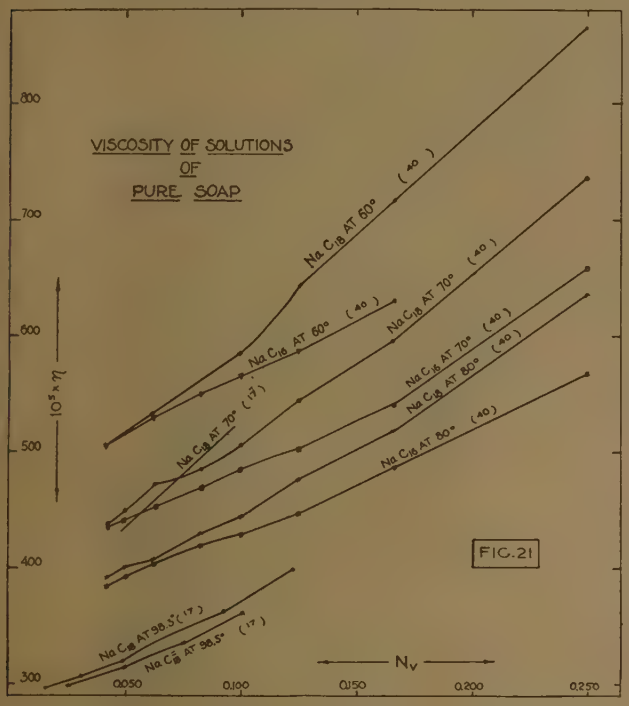
* d_{16}^{16}.

VALUES OF d_4^t

N_v =	0.0001	0.001	0.01	0.05	Lit.
NaC_6, d_{15}^{15}	0.9991	0.9991	1.001	1.003	(54)
NaC_9, 20°	0.9484	0.9985	0.9986		(30)
NaC_{12}, 25°			0.9973	0.9985	(70)
NaC_{18}^-* 23.8°	0.9973	0.9973	0.9974	0.9977	(66)

N_v =	0.1	0.5	0.75	1.0	1.5	Lit.
NaC_6, d_{15}^{15}	1.004	1.020	1.031	1.040	1.057	(54)
NaC_{18}^-,* 23.8°	0.9981	1.0011	1.003	1.005		(66)

* Concentrations are weight-normal (N_w).



SOLUTIONS OF SOAPS WITH ADDITIONS OF ALKALI, FATTY ACID AND SALTS

NaC_9 (30); NaC_{12} (70); KC_x, x = 6, 8, 10, 12, 14, 16, 18 (16); KC_{12} (109); NaC_{16} (18, 44, 89, 91); NaC_{18}^- (32).

Surface Tension

INTERFACE AIR-AQUEOUS SOLUTION

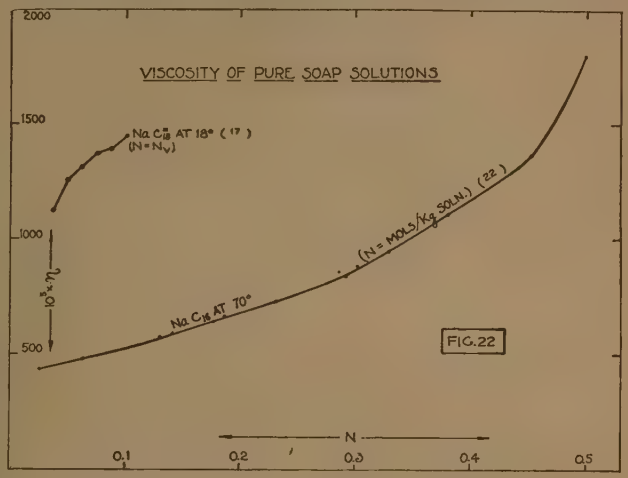
Sodium oleate has been by far the most frequently and carefully measured, but rarely are the effects of age of solution and of age of surface mentioned. For the effect of the latter, *v.* (42). Values of γ in dyne/cm for aqueous solutions of various soaps are shown in Figs. 23, 24 and 25. For mixtures of soaps in water at 60°C, *v.* (126).

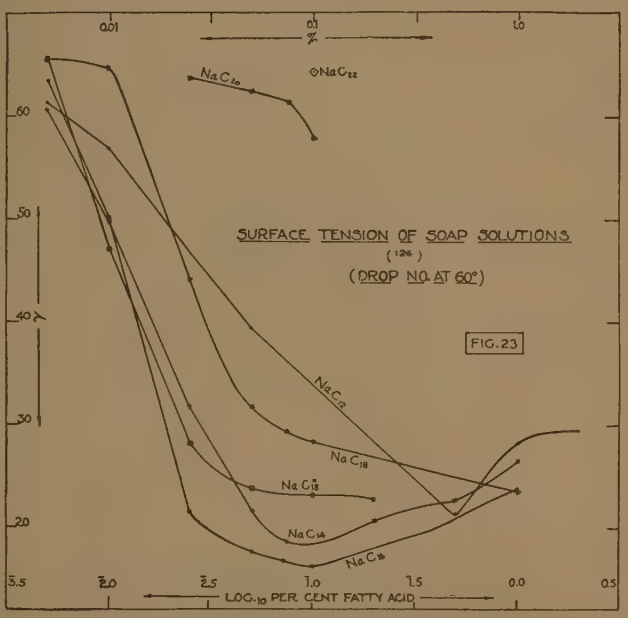
Additional Lit.: NaC_{18}^- (7, 10, 31, 42, 63, 94, 95, 96, 97, 101, 102, 110, 111, 126, 129); NaC_{16} (127); NaC_{18} (8, 127); NaC_9 (30); KC_{18}^- (8, 11); $NaC_{6\text{ to }10}$ (12); MgC_{18}^- (31).

LIQUID-LIQUID INTERFACE

See (19, 31, 32, 43, 63, 103, 113, 114, 117) and Vol. IV, p. 438. In no case have the compositions of both phases been completely determined and all factors controlled. For example, interfacial tension of benzene against aqueous solutions of NaC_{18}^- at 20°C (32):

$10^3 N_v$	0.0	0.1	0.25	0.5	1.0	2.5	5.0	10.0	100
γ	35.0	32.6	22.6	19.5	10.8	5.37	2.76	2.29	1.46

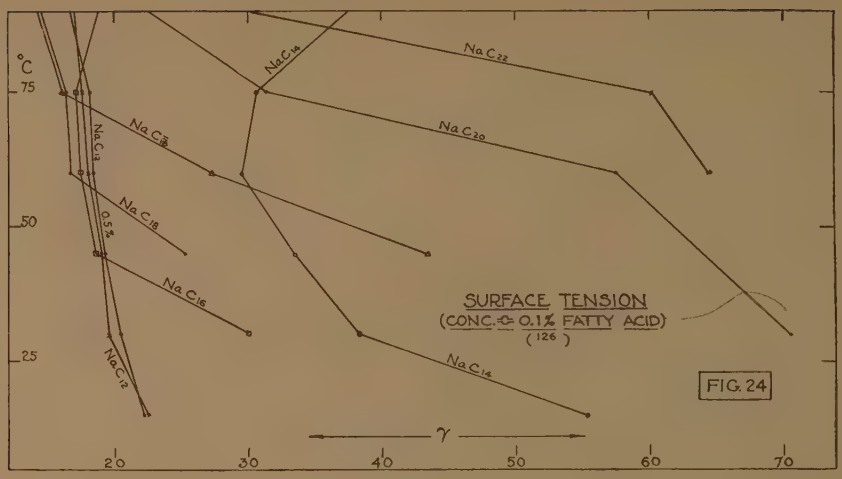


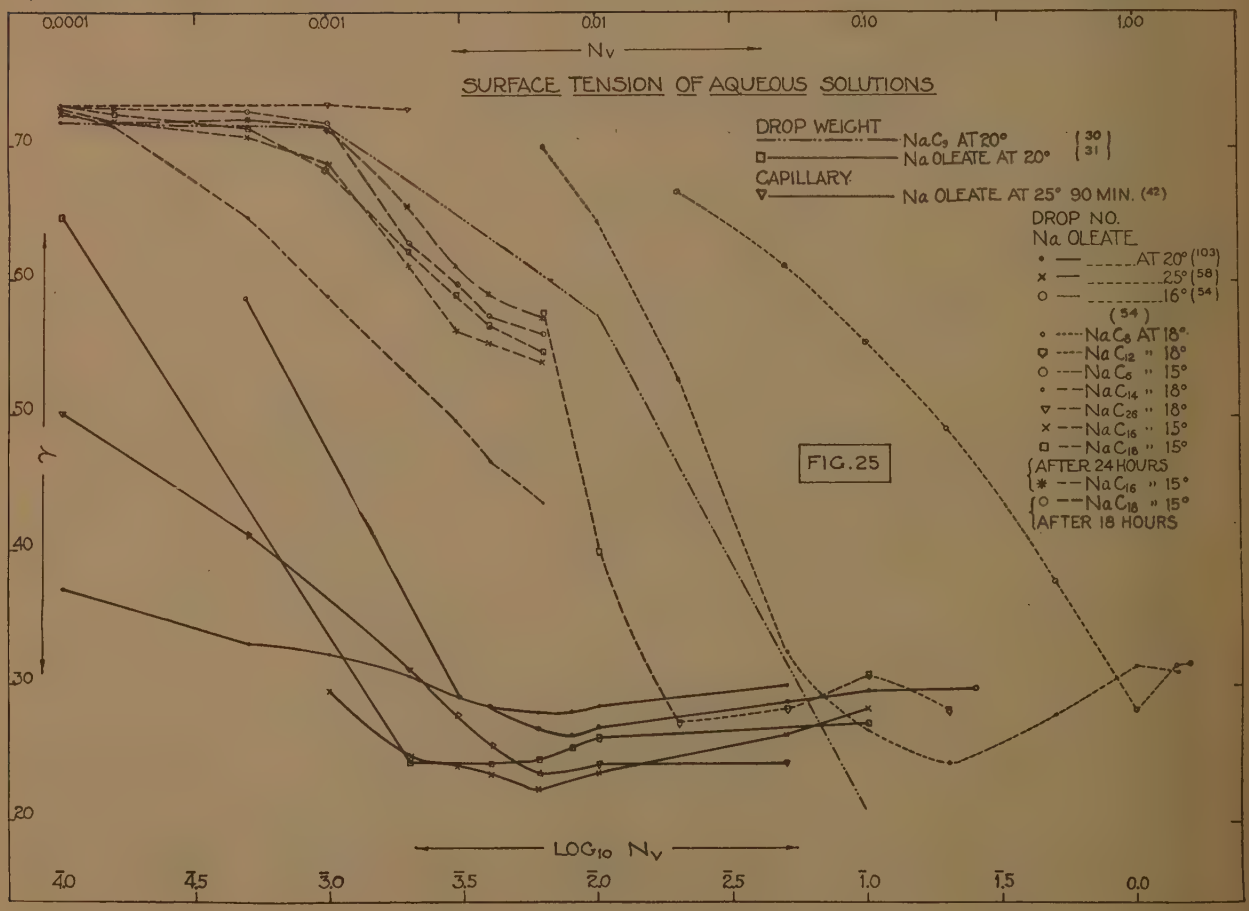


Melting Points of the Pure Soaps

MP_1 is the melting point to form an anisotropic liquid, MP_2 the transition to an isotropic liquid.

Soap (125)	MP_1, °C	MP_2, °C	Soap (125)	MP_1, °C	MP_2, °C
NaC_6	225	350	NaC_{14}	240	330
NaC_7	240	350	NaC_{16}	220	265
KC_7	225	(400)	NaC_{18}	225	270
NaC_8	225	355		215	316
NaC_9	218	242	NaC_{18}	220	305
NaC_{10}	220	318	KC_{12} (73)	264	276
NaC_{12}	229	310			


°C
75
50
25
NaC14
NaC22
NaC20
NaC8
NaC12
NaC18
0.5%
NaC16
NaC12
NaC14
SURFACE TENSION
(CONC. = 0.1% FATTY ACID)
(126)
FIG. 24
γ
20
30
40
50
60
70


0.0001
0.001
0.01
0.10
1.00
Nv
SURFACE TENSION OF AQUEOUS SOLUTIONS
DROP WEIGHT
NaC9 AT 20° (30)
Na OLEATE AT 20° (31)
CAPILLARY
Na OLEATE AT 25° 90 MIN. (42)
DROP NO.
Na OLEATE
AT 20° (103)
25° (58)
16° (54)
(54)
NaC8 AT 18°
NaC12 " 18°
NaC6 " 15°
NaC14 " 18°
NaC26 " 18°
NaC16 " 15°
NaC18 " 15°
AFTER 24 HOURS
NaC16 " 15°
NaC18 " 15°
AFTER 18 HOURS
FIG. 25
γ
70
60
50
40
30
20
LOG10 Nv
4.0
4.5
3.0
3.5
2.0
2.5
1.0
1.5
0.0

Melting Points.—(*Continued*)

Soap	MP, °C	Soap	MP, °C
(46)		AgC_{16}	209 (39)
NaC_{12}	255–260	AgC_{18}	205 (39)
NaC_{14}	250	(98)	
NaC_{16}	270	PbC_6	73.5
NaC_{18}	260	PbC_7	91
$NaC_{18}^{=}$	232–235	PbC_8	84
Na elaidate	225–227	PbC_9	94.5
Na erucate	230–235	PbC_{10}	100
Na brassidate	245–248	PbC_{12}	103.5
(39)		PbC_{14}	107
PbC_{12}	104.7	PbC_{16}	112
PbC_{14}	108.7	PbC_{18}	125
PbC_{16}	112.3	$PbC_{18}^{=}$	45–50
PbC_{18}	115.7	(59)	
MgC_{12}	150.4	NH_4C_8	70–85
MgC_{14}	131.6	NH_4C_{12}	75
MgC_{16}	121.5	NH_4C_{14}	79–90
MgC_{18}	132	$NH_4C_{18}^{=}$	57.5
LiC_{12}	229.5	CuC_{16}	>100
LiC_{14}	223.9	$CuC_{18}^{=}$	100
LiC_{16}	224.5	For MgC_{16} and MgC_{18}, *v.* (36); for other NH_4 soaps, *v.* (13); for mixtures of NaC_{16} and HC_{16}, *v.* (20).	
LiC_{18}	221		
AgC_{12}	212.5		
AgC_{14}	211		

Phase Equilibria

Systems soap-water and soap-water-salt

Explanatory Notes.[1]—Any soap mixed with water in various proportions and under suitable conditions, can be made to assume any one of five different forms, each of which behaves as a single phase when in equilibrium with another phase. They are: (1) Lamellar crystals of soap. (2) The crystalline curd fibers of soap curd. (3) "Neat soap"—clear, transparent, plastic anisotropic liquid. (4) "Middle soap"—anisotropic. (5) Isotropic soap solutions, which includes all the more dilute solutions.

Addition of the third component, salt, introduces no new forms but the limits of concentration for the existence of the separate phases are affected.

Figures 26, 27 and 28 illustrate the limits of existence and the compositions of the various forms of soap solution with varying temperatures in the two-component system, soap-water. Figures 29–34 are the equilibrium diagrams for systems soap-water-salt at various fixed temperatures. Compositions on these triangular diagrams are in "mole fractions" based upon a fictitious molecular weight of 1000 for H_2O and using the gram-formula-weights for the soap and the salt.

Similar phase-rule diagrams (such as Figures 35, 36 and 37) have been partially constructed for commercial soaps from the scattered fragmentary data of the early workers (4, 93, 115, 123, 124); *see also* (1), demonstrating that the phase rule is of general application to all soaps, pure and commercial, and that the same phases occur in every soap system, the limits of concentration for the existence of each phase varying with the soap.

Tables 1–4 show the relative and minimum absolute amounts of various salts required to produce phase separation at 100°, Tables 1–3 referring to formation of liquid layers and Tables 3 and 4 to beginning separation of crystalline curd fibers. These ratios are approximately independent of the nature of the soap. The effects of mixtures of electrolytes are approximately additive. A mixture of soaps behaves as expected from the constituents when forming liquid layers but not when crystallizing in either curd or fiber form. These rules applied to the tables enable approximate prediction of the behavior of any soap or soap mixture. The following are maximum concentrations of salt for the formation of the liquid-liquid system nigre-lye with soaps made from separate oils studied by Merklen (93) the numbers being accurate to 0.1 or 0.2 of the values given: Sesame oil 6.8, olive 8.1, poppy seed 6.6, poppy seed reheated 7.7, lard 6.0, lard without salt 7.2, tallow 7.0, linseed 7.5, sulfur oil 13.3, saponification olein 8.6, saponification olein with glycerol 9.1, saponification stearin 6.2, cottonseed oil 8.9, peanut oil 6.7, castor oil 25.1, castor oil and peanut oil 17.6%.

[1] For full discussion, *see* (1).

TABLE 1 (1, 115).—MINIMUM NUMBER OF GRAMS OF VARIOUS ELECTROLYTES IN 100 Cm^3 OF LYE AT 100° REQUIRED TO MAINTAIN TWO LIQUID LAYERS (NIGRE AND LYE) FROM POTASSIUM AND SODIUM SOAPS, IN DILUTIONS BETWEEN $N/8$ AND $N/4$ (1).

Electrolyte	KOH*	KCl	K_2CO_3	NaOH	NaCl†	Na_2CO_3
Stearate C_{18}	7	8	13	3		6
Oleate $C_{18}^{=}$	8		15	4	5	7
Palmitate C_{16}	10	12	18	4	5	8
Linolate $C_{18}^{=}$	10	13	19			
Myristate C_{14}	15	20	26	8	8	16
Laurate C_{12}	21		34	12	13	
Ratios	1.50	2.00	2.78	0.87	1.00	1.84

N.B.—An equal mixture of sodium oleate and sodium myristate is half way between pure sodium oleate and pure sodium myristate.

* $KC_{22}^{=}$ by 3 g of KOH.

† NaC_{22} by 2.3 g NaCl per 100 cm^3 = $0.4N_w$ (52).

TABLE 2 (83).—CONCENTRATIONS, N_w, OF VARIOUS SODIUM SALTS REQUIRED TO SALT OUT $0.25N_w$ SOLUTIONS OF SODIUM PALMITATE AT 90°.

Anion	N_w	Anion	N_w	Anion	N_w
OH	1.13	Br	0.90	CNS	0.76
NO_3	1.05	$C_2H_3O_2$	0.89	WO_4	0.65
Cl	0.95	CO_3	0.89	Tartrate	0.65
I	0.91	SO_4	0.83		

TABLE 3 (1, 115).—RELATIVE NUMBER OF MOLES OF HYDROXIDE, CHLORIDE, AND CARBONATE OF SODIUM AND POTASSIUM REQUIRED FOR SALTING OUT LIQUID LAYERS OR CURD AT 100°.

	OH	Cl	CO_3
K	1.02	1.00	0.70
Na	1.27	1.00	1.01

TABLE 4 (1, 115).*—MINIMUM NUMBER OF GRAMS OF VARIOUS ELECTROLYTES IN 100 Cm^3 LYE AT 100° FOR CURD FIBERS TO APPEAR IN NEAT SOAP LAYER.

Electrolyte	KOH	KCl	K_2CO_3	NaOH	NaCl	Na_2CO_3
Stearate C_{18}	(17)	13	20	4		7
Oleate $C_{18}^{=}$	10		19.5	4	5	9
Palmitate C_{16}	11		22	5	6	12
Linolate $C_{18}^{=}$	13	19	24			
Myristate C_{14}	18	>23	>38	9	10	17.8
Laurate C_{12}	25		>37	13	14	
Ratios	1.50	2.00	2.78	0.87	1.00	1.84

N.B.—Notice that the values for sodium salts are about half those for the corresponding potassium salts.

* Langdon (78) for NaC_{16} found 7% NaCl, Stiepel (123) for NaC_{12}, NaC_{14}, NaC_{16} and NaC_{18} found 18, 9, 7, and 5% NaCl respectively, as compared with Richert's 14, 10.6 and 5%. Kronacher (25) for NaC_{10}, NaC_{12}, NaC_{14}, NaC_{16} and NaC_{18} found approximately 23, 13, 10, 7 and 5% NaCl.

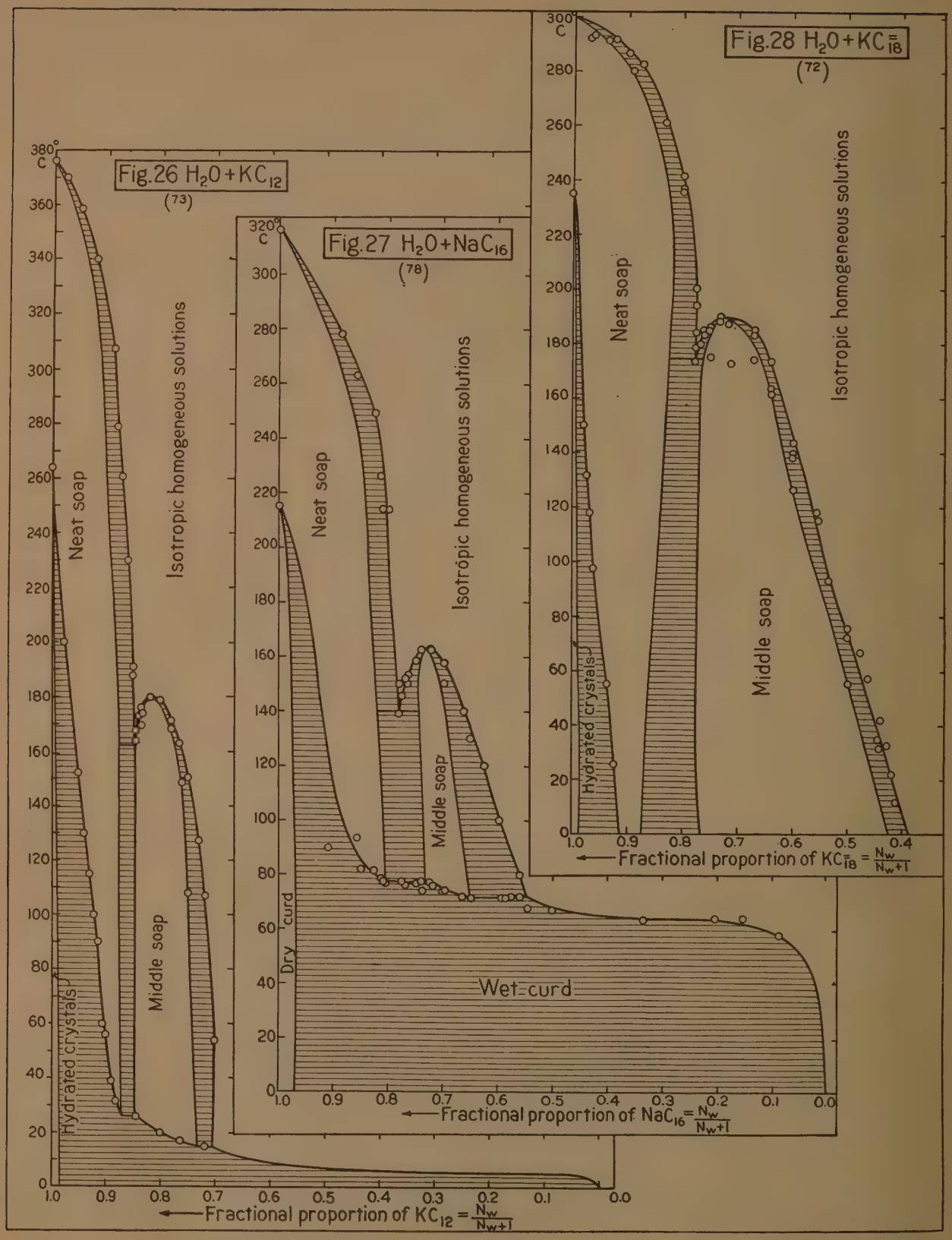


Fig.26 H_2O+KC_{12}
(73)
Fig.27 H_2O+NaC_{16}
(78)
Fig.28 $H_2O+KC_{18}^{=}$
(72)
Neat soap
Isotropic homogeneous solutions
Middle soap
Hydrated crystals
Dry curd
Wet-curd
Fractional proportion of $KC_{12} = \frac{N_w}{N_w+1}$
Fractional proportion of $NaC_{16} = \frac{N_w}{N_w+1}$
Fractional proportion of $KC_{18}^{=} = \frac{N_w}{N_w+1}$

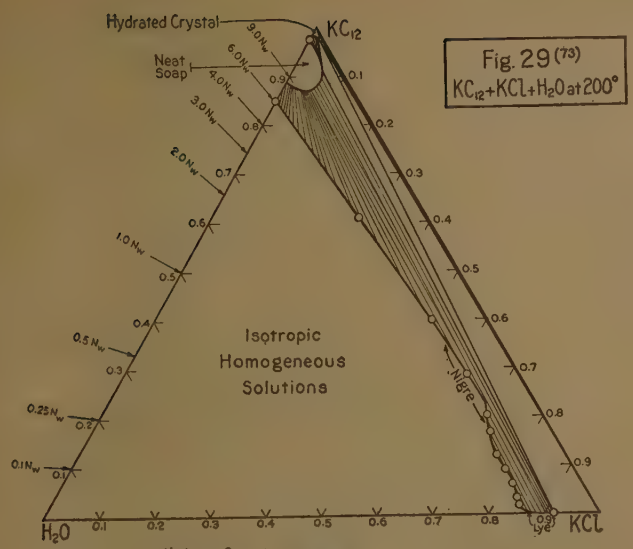


Fig. 29 (73)
$KC_{12}+KCl+H_2O$ at 200°

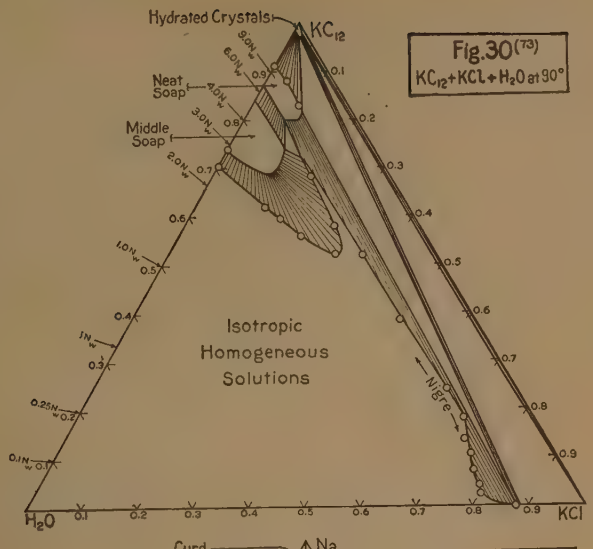


Fig. 30 (73)
$KC_{12}+KCl+H_2O$ at 90°

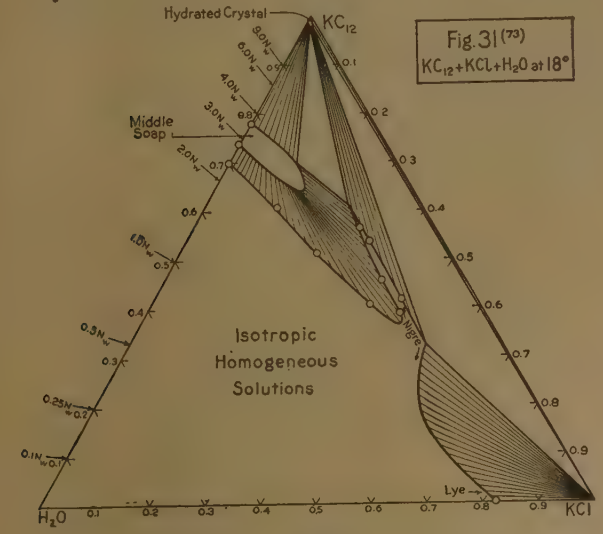


Fig. 31 (73)
$KC_{12}+KCl+H_2O$ at 18°

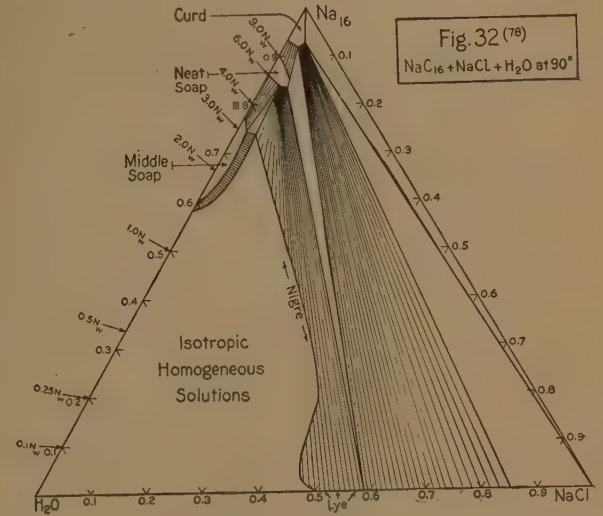


Fig. 32 (78)
$NaC_{16}+NaCl+H_2O$ at 90°

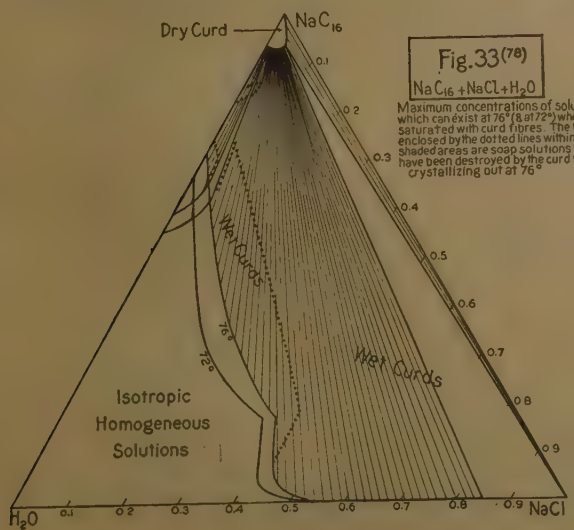


Fig. 33 (78)
$NaC_{16}+NaCl+H_2O$

Maximum concentrations of solutions which can exist at 76° (& at 72°) when not saturated with curd fibres. The fields enclosed by the dotted lines within the shaded areas are soap solutions which have been destroyed by the curd fibres crystallizing out at 76°

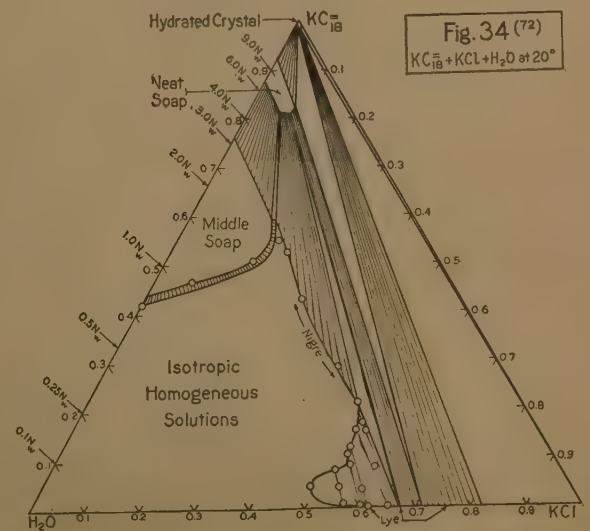
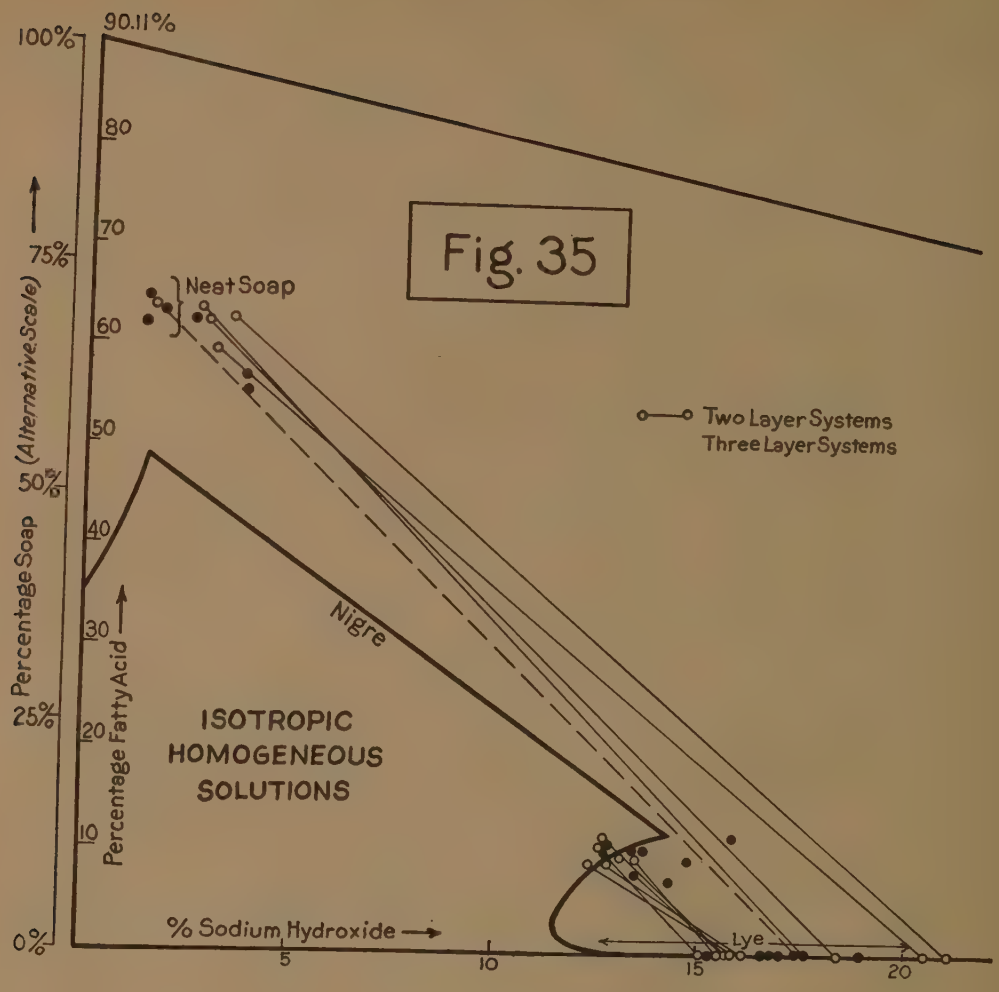


Fig. 34 (72)
$KC_{18}+KCl+H_2O$ at 20°



Solubility

Any soap, pure or commercial, mixed with water or with water and an electrolyte can be made to exist as either lamellar soap crystals or curd fiber crystals; both are usually hydrated, and more than one hydrate may occur. On raising the temperature the crystals or curd dissolve to form ordinary isotropic solution, middle soap, or neat soap depending upon the concentration. The data usually refer to the form of hydrated crystals most stable under the experimental conditions.

HYDRATED CURD FIBERS; TEMPERATURE OF COMPLETE SOLUTION TO FORM ISOTROPIC SOLUTION OF CONCENTRATION, N_w

N_w	°C	N_w	°C	N_w	°C	N_w	°C
NaC_{12} (69)		NaC_{16} (78)		KC_{18}^{-} (10)		KC_{12} (73)	
2.0	45	10.0	(90)	15	55	8.004	39.0
1.0	40	1.009	67	12	26	8.878	56.0
0.2	34	0.504	63	KC_{12} (73)		9.694	60.0
0.1	31	0.01	51	2.508	15	10.98	90.0
NaC_{18}^{-} (53)		KC_{18}^{-} (72)		3.222	17.5	11.52	100
0.6	25	50	150	4.004	20.0	12.96	100
0.4	23	40	132	5.373	25.5	16.14	130
0.2	21	30	118	5.653	26.0	19.36	152
0.1	18	25	98	7.226	32.0	43.32	200

FIGS. 35 and 36 (1).—A reinterpretation (by J. W. McBain) of M. Thörl's laboratory experiments with sodium hydroxide on the salting out of soap prepared from coconut oil at 100°C showing how they accord with phase-rule diagrams for the pure soaps.*

* The boundary line of the isotropic solutions is sketched in an identical position in diagrams 35, 36 and 37 and takes account of results of Perkowski quoted by Richert. Results of Thörl, Bätz, Richert and Perkowski are not true per cent but grams per 100 cm^3 of solution measured at 100°C. The data of Penny and Elford are grams per 100 grams of total system.

SOLUBILITY OF HYDRATED CURD FIBERS IN TERMS OF N_w OF MOTHER LIQUOR IN CURD AFTER SOLIDIFICATION ($=N_w$ IN TABLE)

Soap	Orig. N_w	N'_w	t, °C	Lit.
NaC_{10}	2	1	15	(12)
NaC_{16}	0.1914	0.01778	30	(53)
	0.25	0.00819	25	
NaC_{16}*	0.25	0.03	17–25	(6)
	1.0	0.1	17–25	
NaC_{16}	0.005–0.0004	0.0003	17	(112)
NaC_{18}^{-}	0.6	0.39	18	(53)
		0.26	10	
		0.114	0	
	0.1905	0.0998	18	

* NaC_{16} dissolved in 0.6 N_w aqueous glycerol.

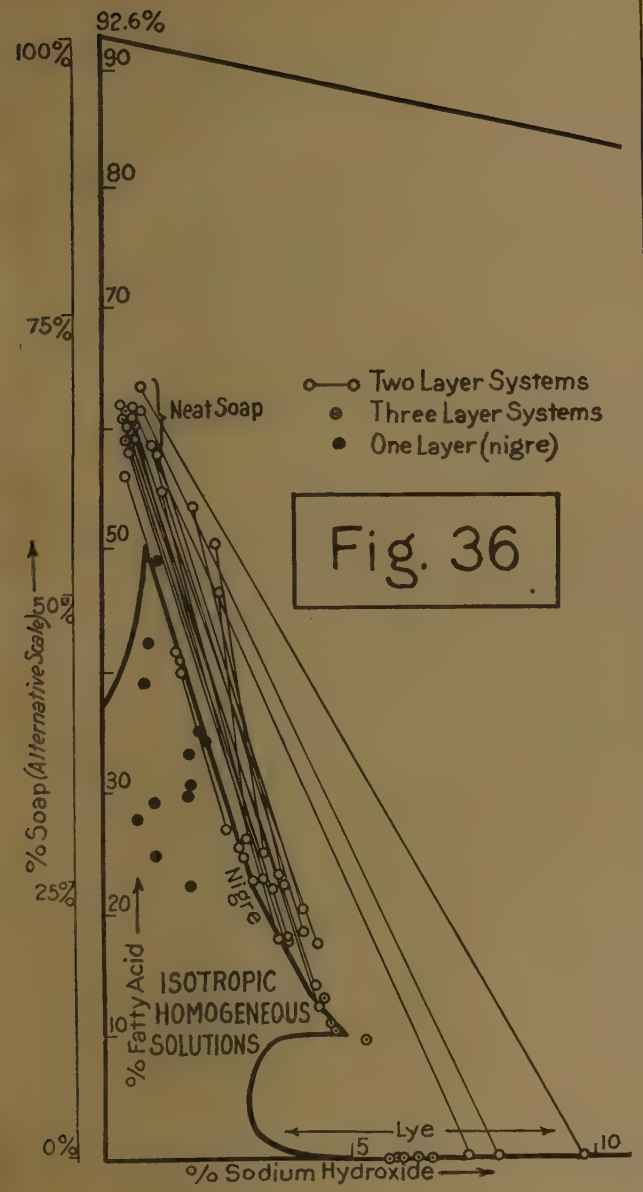


Fig. 36

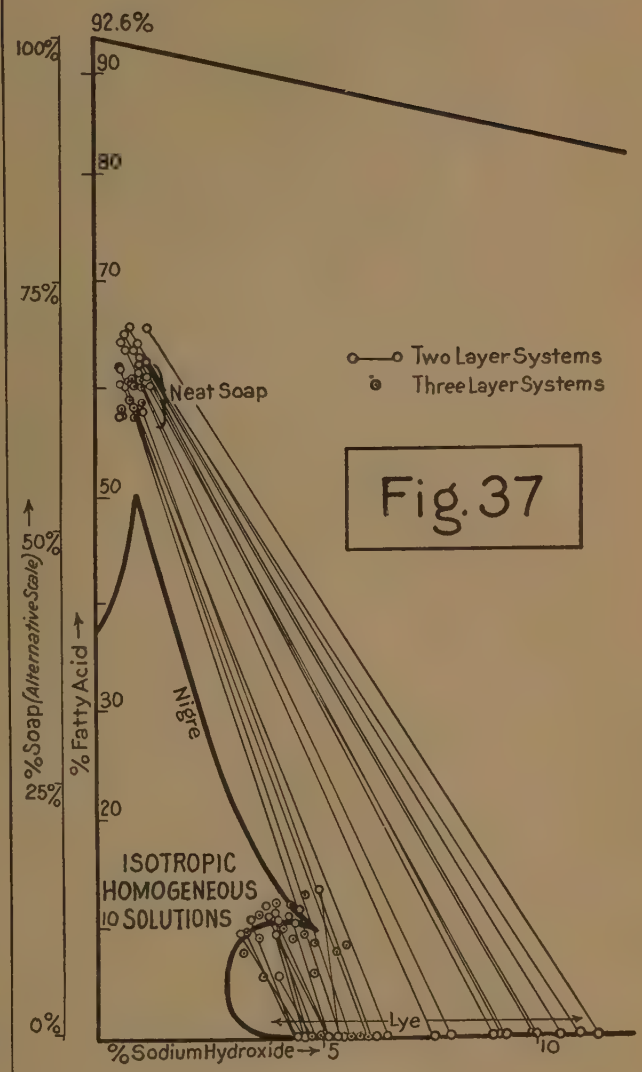


Fig. 37

SOLUBILITY OF CURD FIBERS AS DETERMINED FROM FATTY RADICAL FROM CURD

Soap	N_w Curd	N_w Ultrafiltrate	t, °C	Lit.
NaC_{16}	0.04–0.009	0.0003	18	(55)
	0.003–0.006	0:00023	18	
KC_{16}	0.034	0.0002	22	(50)
NaC_{18}	0.065	0.0004–0.0006	14–18	(50)
	0.03	0.0001*	18–22	
	0.03	0.0004–0.0005	14–18	
	0.0018	0.0001	14–18	

* Assumed by Kratz to be correct solubility.

TEMPERATURE OF SPONTANEOUS SEPARATION OF NA SOAP (CURD FIBERS) FROM AQUEOUS SOLUTION ON COOLING, °C (47)

Soap, g per 100 g H_2O	C_{18}	C_{16}	C_{14}	C_{12}	$C^{=}_{18}$	Elaidate	$C^{=}_{22}$	Brassidate
1	60°	45°	32°	11°	0°	35°	27°	42°
20	69°	62°	53°	(36°)	*ca.* 13°	45°	35°	56°

(12)	3	2	1.5	1	$0.75N_v$
NaC_9	13–14°	10–11°	−1°	<0°	
NaC_{10}		16°	3–4°	2.3°	>0°

Also (108); 6% NaC_{12} at 26°, 1% NaC_{16} at 43°, 6% NaC_{16} at 52°, 1% NaC_{16} + 6% NaC_{12} at 8°, 1% NaC_{16} + 1% NaC_{12} at 29°; (3) NaC_{16}, 0.1 N_w at 58°, 0.5 N_v at 65°; KC_{16}, 0.5 N_v at 38°C; (12) 62.5 g anhyd. NaC_{12} in 100 g H_2O at 12–18°.

Solubility.—(*Continued*)

TEMPERATURE OF COMPLETE SOLUTION OF HYDRATED CRYSTALLINE CURD FIBERS IN AQUEOUS NaCl SOLUTIONS

NaC_{12} (69)			KC_{12} (73)		NaC_{16} (78)		
N_w soap	N_w NaCl	°C	N_w soap	°C	N_w soap	N_w NaCl	°C
2.0	0.534	57	N_w KCl = 0.5		3.02	0.293	(77)
	0.62	56	6.01	(21.0)	1.01	.680	76
	1.02	60	6.99	29.0	0.504	.794	74
	1.02	63.5	7.46	35	.504	.55	72
	1.92	68	8.76	50	.504	.642	76
1.0	0.49	48	9.77	65	.503	.738	75.5
	1.59	60	11.2	90	.399	.906	76
	1.66	65	12.6	100	.351	.835	75
	1.71	62	20.0	115	.206	.836	74
	1.86	63	N_w KCl = 1.0		.135	.819	72.5
	2.10	66	6.01	24.5	.0610	.807	72.5
0.20	1.21	55	7.91	50.5	.058	.908	(75)
	1.56	60	8.93	79.0	NaC_{22} (52)		
	2.05	61	9.8	90.0	0.05	0.42	100
0.10	1.97	60	15.0	98.0	0.05	0.59	100
	2.08	61	N_w KCl = 2.0				
	2.19	62	5.02	33.5			
			5.97	35.2			
			7.70	41.5			

GRAMS OF SOAP IN 100 GRAMS OF WATER AT VARIOUS TEMPERATURES

	15°	25°	50°	100°C	Lit.
LiC_{12}		0.180	0.280		(39)
LiC_{14}		0.036	0.060		(39)
LiC_{16}		0.015			(39)
LiC_{18}		0.010			(39)
SrC_6* + $3H_2O$		8.89 (at 24°)			(45)
MgC_{12}	0.009	0.009	0.026		(39)
MgC_{14}	0.006	0.006	0.014		(39)
MgC_{16}	0.005	0.005	0.009		(39)
MgC_{18}	0.003	0.004	0.008		(39)
MgC_{18}^{-}	0.022	0.024	0.03		(92)
Mg erucate		0.006			(123.5)
BaC_6	8	7	8		(29, 60, 116)
BaC_7	1.6	1.6	1.6		(60)
BaC_{12}	0.008	0.009	0.011		(39)
BaC_{14}	0.007	0.008	0.010		(39)
BaC_{16}	0.004	0.005	0.007		(39)
BaC_{18}	0.004	0.005	0.006		(39)
CaC_6	2.4	2.3	2.3	2.57	(29, 60, 61, 116)
CaC_7†	0.84	0.81	0.80	1.24	(60, 116)
CaC_8	0.31	0.29	0.26	0.50	(116)
CaC_{18}^{-}	0.04	0.04	0.03		(92)
ZnC_6 + H_2O		1.03 (at 24.5°)			(45)
CdC_6 + $2H_2O$		0.96 (at 23.5°)			(45)
PbC_{12}			0.007		(39)
PbC_{14}			0.006		(39)
PbC_{16}			0.007		(39)
PbC_{18}			0.006		(39)
AgC_6	0.09	0.12	0.20		(60, 116)
AgC_7	0.09	0.11	0.17		(60, 116)
AgC_{14}			0.007		(39)
AgC_{16}			0.006		(39)
AgC_{18}			0.004		(39)

* Caproic acid from fermentation butyric acid.

† *See also* Landau, 1893, and Altschul, 1896 (116).

ADDITIONAL DATA

Fahrion (21) 1 l water at 15° dissolved 90 mg of CaC_{18}^{-} and 224 mg MgC_{18}^{-}. Blumercron (12) curding of solutions of NaC_6, NaC_7, NaC_8, NaC_9, NaC_{10}, at 20° on addition of NaCl and NaOH. Partheil and Ferié (107), LiC_{12}, LiC_{14}, LiC_{16}, LiC_{18}^{-} at 18° and 25°. Oudemans ((59) p. 159) Mg, Ca, Sr, Ba, Zn, Pb, Mn, Co, Ni, Cu, Ag salts of C_{12} at 15° and at boiling point. Lewkowitsch ((59) p. 143, 157) CaC_6, CaC_8, CaC_{10}, CaC_{12} at 20° or 100°. Jensen (41) AgC_8, AgC_{10} at 20° in water and $\frac{1}{20}N$ $AgNO_3$ solution. Altschul ((116) p. 614) AgC_7, 0–80°. Lieben and Janecek (61) CaC_6, BaC_6 at 10–12°. Zsigmondy and Bachman (130) NaC_{16} in water. McBain, Cornish and Bowden (70) NaC_{14} in water. Kottal (45) CaC_6, BaC_6.

Freezing-Point Lowering

Values of k_F, $= \Delta t_F/N_w$, where Δt_F is the freezing-point lowering in °C at the concentration N_w moles per kg H_2O (52).

Soap	N_w	Δt_F	Soap	N_w	Δt_F
KC_{12}	0.05	0.177	KC_8	3.0	4.71
	.1	.212	NaC_{18}^{-}	0.4	0.146
KC_{18}^{-}	.6	.348		.2	.095
	.4	.215	NaC_{22}	.05	.036
NaC_8	1.0	2.445			

See further, Fig. 38.

Boiling-Point Elevation

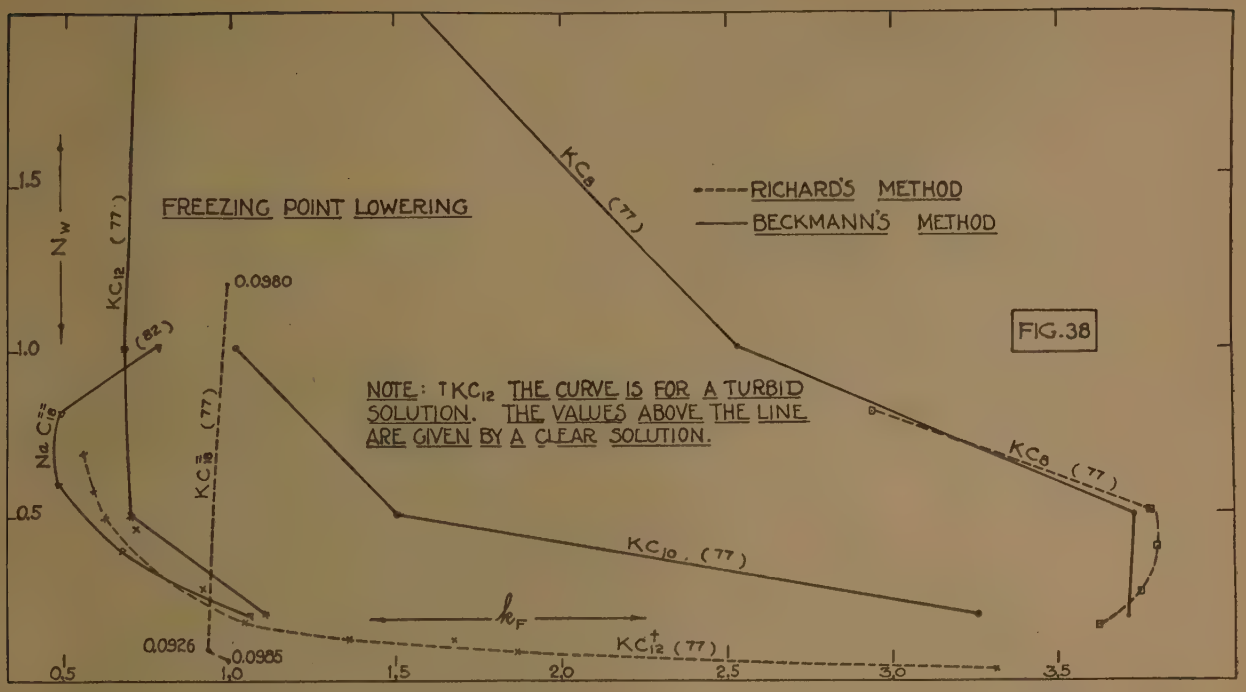
Values of $k_B = \Delta t_B/N_w$, where $\Delta t_B = t_s - t_w$, t_s being the temperature at which the partial vapor pressure of water from the solution is equal to the vapor pressure of pure water at t_w, °C. The data for the higher temperatures (t_w = 90 – 100°C) are shown graphically in Fig. 39. Some values at lower temperatures are given in the following table:

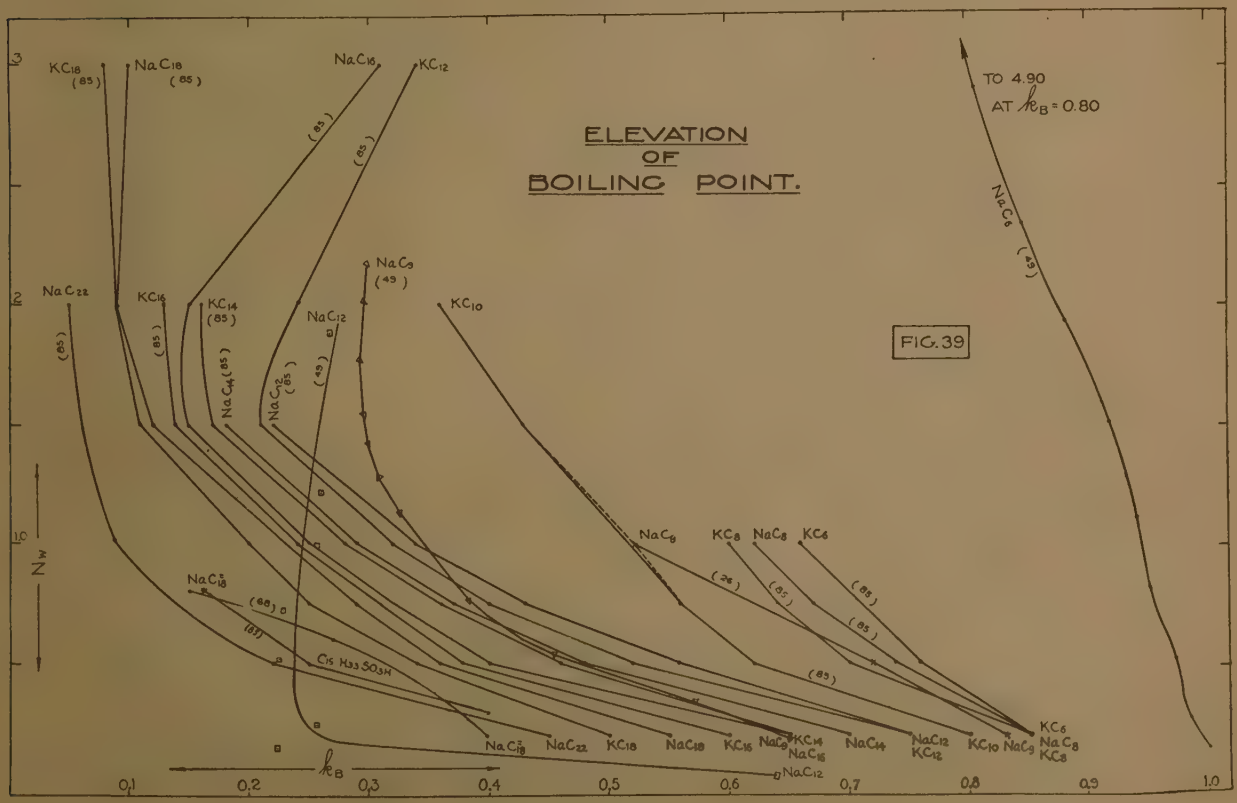
Soap*	t_w, °C	N_w	k_B	Lit.
KC_8	20	3.0	0.23	(77)
NaC_{12}	43	1.5	.20	(86)
NaC_{12}	40	1.5	.20	(86)
KC_{12}	20	0.2	.20	(77)
NH_4C_{12}	20	1.0	.17	(77)
NH_4C_{12}	20	0.5	.16	(77)
NaC_{16}	67	1.0	.26	(86)
NaC_{16}	70	1.0	.26	(86)
KC_{16}	33	0.5	.34	(86)
NH_4C_{16}	20	1.0	.06	(77)
NH_4C_{16}	70	1.0	.23	(85)
NaC_{18}	18	0.6	.10	(53)
NaC_{18}^{-}	18	0.4	.10	(53)
KC_{18}^{-}	20	0.6	.12	(77)
K elaidate	20	0.75	.24	(68)
K elaidate	20	0.5	.26	(68)
K elaidate	20	0.2	0.6–0.8	(68)
$NaC_{18}^{-}OH$	20	1.0	0.21	(68)
$NaC_{18}^{-}OH$	20	0.75	.25	(68)
$NaC_{18}^{-}OH$	20	0.5	.34	(68)
$NaC_{18}^{-}OH$	20	0.2	.35	(68)
NaC_{18}^{---}	20	0.5	.20	(68)
NaC_{18}^{---}	20	0.2	.075	(68)

* For solutions of soap with various added constituents, *v.* (46, 77, 85, 89, 109).

Refractive Index (62)

The specific refraction, $R = (n - 1)/d$ or $R' = (n^2 - 1)/d \times (n^2 + 2)$ for soap in soap solutions at 70° is for any one soap independent of concentration (and also of solvent), the molecular refraction for the soap in solution being equal to that calculated for the pure anhydrous liquid soap. Concentrations between 2.4 and 17.8 g/100 cm³ aqueous solution.


FREEZING POINT LOWERING
RICHARD'S METHOD
BECKMANN'S METHOD
NOTE: †KC12 THE CURVE IS FOR A TURBID SOLUTION. THE VALUES ABOVE THE LINE ARE GIVEN BY A CLEAR SOLUTION.
FIG. 38
KC8 (77)
KC12 (77)
KC10 (77)
KC12† (77)
NaC18= (82)
0.0980
0.0926
0.0985
Nw
kF
1.5
1.0
0.5
0.5
1.0
1.5
2.0
2.5
3.0
3.5


ELEVATION OF BOILING POINT.
FIG. 39
TO 4.90 AT kB = 0.80
KC18 (85)
NaC18 (85)
NaC16
KC12
NaC22
KC16
KC14 (85)
NaC14 (85)
NaC12 (85)
NaC9 (49)
KC10
NaC6 (49)
NaC8
KC8
NaC8
KC6
NaC18= (68)
C15 H33 SO3H
NaC18=
NaC22
KC18
NaC18
KC16
NaC9
KC14
NaC16
NaC14
NaC12
KC12
KC10
NaC9
KC6
NaC8
KC8
NaC12
Nw
kB
3
2
1.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0

Refractive Index.—(*Continued*)

Soap	R_C	R_D	R_F	R'_C	R'_D	R'_F
NaC_{16}		0.480			0.289	
NaC_{16}	0.467	0.471	0.476	0.283	0.284	0.286
KC_{16}		0.471			0.284	
NaC_{18}		0.475			0.287	
$NaC^{=}_{18}$	0.475	0.480	0.484	0.286	0.288	0.290

Electrical Conductivity of Aqueous Solutions

The values given are $\Lambda = 10^3\kappa/N_v$ where κ is the specific conductance of the solution in mhos

NA SOAPS AT 90°C

N_w =	1.5	1.0	0.75	0.5	0.2	0.1	0.05	0.01	Lit.
NaC_8		106.9		(127.5)	150.44	166.42	196.0	199.8	(26)
NaC_{12}	96.2	104.2		109.5	113.4	125.5	157.0	193.9	(70)
NaC_{14}	84.76	94.93	97.57	99.15	95.23	96.51	110.4	191.7	(70)
NaC_{16}	84.5*	83.6	85.8	87.4	79.4	75.5	76.4	101.7	(80)
NaC_{18}	81.5	88.3		76.1	77.4	76.0	78.0	125.9	(14, 70)
NaC_{22}				80.96	61.99	67.09	78.58	141.7	(26)

* From (87).

NaC_{14} (70)						NaC_{16} (3)		
N_w	80°	70°	60°	50°	40°C	°C	N_v 0.01	N_v 0.1
1.5	75.1	65.4	55.2	44.8		85	114.7	73.1
1.0	84.3	73.6	62.2	51.5		75	99.9	64.3
0.5	87.5	74.6	62.3	52.1		65	85.1	55.4
0.2	84.0	71.5	59.8	50.0	40.0	55	72.6	46.8
0.1	85.1	72.6	60.6	50.7	40.5	45	66.3	
0.05	97.3	83.1	69.4	58.0	46.5			
0.01	169.0	144.3	120.5	100.6	80.3			

$NaC_{16}SO_3$ (112)

N_v	65°	60°	55°	50°	45°	40°C
0.0666	45	41.5	38.6	35.6	32.3	29.5
0.0333	46	42.1	39.1	35.5	32.6	29.4
0.01665	51.6	47.2	42.7	39.1	34.9	31.4

$NaC^{=}_{18}$ AT 25° (55)

$1/N_v$	5	10	30.25	60.50	121	242	484	968
Δ	22.09	20.1	20.9	25.95	34.1	47.1	57.6	61.6

$NaC^{=}_{18}$ AT 18° (112)

10^3N_v	66.70	33.35	16.67	8.34	4.17	2.08	1.04	0.52
Δ	19.27	20.67	23.58	28.08	38.40	49.44	54.72	61.44

$NaC^{=}_{18}$ (IDENTICAL FOR SOL AND JELLY) (53)

°C	5.0	10.0	15.0	18.0	22.0	25.0
$0.4N_w$	13.94	16.22	19.13	20.95	22.62	25.84
$0.6N_w$	15.10	16.95	20.35	21.65	22.64	25.97

NA SOAPS AT 18°

N_w	1.0	0.6	0.4	0.2	0.1	0.05	0.01	Lit.
$C^{=}_{18}$		21.67	20.80	19.77	20.46	20.59	30.09	(77)
$C^{=}_{18}$*	26	30.1	29.6	28.9	29.0	30.5	49.60	(66)
$C^{=}_{18}$			29.6	28.70	29.13			(84)
$C^{=}_{18}OH$†	27.7	32.1	34.0	35.8	37.8	40.7		(71)

* At 24°C. † $1.5N_w$ 23.1, and 24° (79); $1.0N_w$ 35.5; $0.5N_w$ 43.8.

K SOAPS AT 90° (16)

N_w =	1.0	0.75	0.5	0.2	0.1	0.05	0.02	0.01
C_6	149.5		177.7	201.2	216.5	227.7	(241.2)	245.9
C_8*	148.7		168.5	191.0	205.2	219.2	(234.5)	239.5
C_{10}	145.9		156.3	180.9	200.6	211.9	(227.0)	232.4
C_{12}†	143.2	142.6	146.0	144.2	159.7	195.9	(223.5)	233.0
C_{12}‡	136.2	144	147	136.6	162	191		
C_{14}	136.2		135.4	130.8	121.8	136.6	181.6	224.3
C_{14}‡	138	132	127	120	117	117		

K SOAPS AT 90°.—(*Continued*)

N_w =	1.0	0.75	0.5	0.2	0.1	0.05	0.02	0.01
C_{16}	124.2	127.9	127.0	111.0	107.0	110.8	133.2	171.6
C_{18}	113.4	112.6	113.9	100.0	96.0	101.7	124.9	147.7
C_{18}‡			126	117	114.5	113		

* 107.3 at $3.063N_w$. † 123.5 at $2.028N_w$. ‡ Concentration N_v (51).

K SOAPS (51)

°C	N_v at 90° =	0.05	0.1	0.2	0.375	0.4	0.6	0.8	1.0
60	C_{12}	123.6	105	93.9	102.8	103	106	104.5	99.6
	C_{14}	77.1*	77.4	77.6	88.5	90.1	95	92.9	89
	$C^{=}_{18}$	80.3†	81.5	77.0	86.3	87.5	88.6		
45	C_{12}	95.4	83.0	74.3	82.3	81.8	88.5	83.6	79.5
	C_{14}	57.9*	58.7	60.9	69.5	70.7	75	74.2	72.0
	$C^{=}_{18}$	61.0†	60.7	60.4	67.7	68.8	70.7		
30	C_{14}	47.7*	47.2	46.2	51.6	52.5	55.9	56.0	54.9
20	C_{12}	59.1	50.0	44.8	50.6	50.8	53.7	52.0	52.1
	C_{14}	35.7*	39.5	33.0	35.5	36.0	38.4	41.4	45
	$C^{=}_{18}$	37.1†	36.9	35.5	39.9	40.5	42.6		

* $N_v = 0.054$. † $N_v = 0.0518$.

KC_{16}; EFFECT OF TIME (3); *see further* (53)

°C	85	75	65	55	45	35	25
$0.01N_v$	136.4*	118.8	100.5	86.7	79.6 →	87.6 →	92.8‡
	140.8†						
$0.1N_v$	88.9	78.7	68.4	58.8	49.1	41.0	35.8

* 10 min. † 60 min. ‡ All at 45°, 0 min, 20 min and 24 hr resp.

K SOAPS AT 18°

N_w	2.0	1.0	0.75	0.5	0.2	0.1	0.05	0.01	Lit.
C_8	42.24	48.60	49.75	53.00	63.05	69.50			(77)
C_{12}	43.14	47.09	47.21	45.44	41.77	44.03	54.89	75.4	(77)
$C^{=}_{18}$				37.0	33.30	29.74	29.57	51.95	(77)
Elaidate			38.01	35.83	34.04	35.05	47.35		(90)

$C_{16}SO_3H$ AT 90° (100); *cf.* (112)

N_w	0.75	0.5	0.2	0.1	0.05	0.02	0.01
Δ	237	232.0	203.9	188.1	185.5	195.0	208.0

K AND NH_4 SALTS OF FATTY ACIDS FROM PALM-KERNEL OIL (28, 51)

MOLTEN K AND NA SOAPS (9)

MIXTURES: SOLUTIONS OF SOAPS WITH ADDITIONS OF SALTS, ACIDS AND BASES (3, 24, 27, 28, 51, 70, 89, 109)

Gold Numbers and Detergent Action, *v.* (37, 38, 50, 57, 74, 104, 105, 106, 108, 114, 117, 119, 120, 121, 122)

Hydration

H_2O = moles H_2O per mole soap

Negative sorption from lyes which salt out curd fibers from aqueous solutions of soap, yield the following values expressed as the retention of the solvent assuming that none of the salts are sorbed. The conditions and methods of experiment are described in the reference cited. For negative sorption by NaC_{16} from salt mixtures, *v.* (81).

t, °C	Soap	Orig. N_w	Salt	N_w	H_2O	Lit.
90	NaC_{18}	0.5	NaOH	1.5	4.3	(88)
90	NaC_{16}	1.0	NaOH	3.0	3.4	(88)
		1.0	NaOH	2.0	5.2	
		0.5	NaOH	1.5	6.5	
		1.0	NaOH	0.5	4.4	
			NaCl	2.0		

Hydration.—(*Continued*)

t, °C	Soap	Orig. N_w	Salt	N_w	H_2O	Lit.
17–25	NaC_{16}	1.0	Glycerol	0.6	4.3	(6)
		0.25	Glycerol	0.6	10	
90	NaC_{12}	1.0	NaCl	Satd.	1.8	(86)
12–18	KC_{12}	1.1	KCl	0.6	11.8	(9)
20	KC_{12}	1.1	KCl	0.9	11.3	(64)
		1.6	KCl	0.8	10.1	
		2.6	KCl	0.67	9.4	
20	KC_{12}	1.0	KCl	1.0	11.0	(23)
		1.5	KCl	0.86	10.8	
		2.9	KCl	0.65	8.6	
		1.0	KCl	0.1	24	
12–18	NaC_{18}^{-}	0.25	NaCl	0.1	9.2	(76)

Hydration of soap in solutions of $1.0N_w$ KC_{12} containing known amounts of KCl at 18° by comparison of conductivity, migration, and vapor pressure (109).

KCl added (N_w)	0.5	0.7	1.0	1.5	2.0	2.5	3.0	3.5
H_2O	11 (±1.1)	12.2	12.8	10	9.6	5.2	6.3	6.9

For vapor pressures during hydration and dehydration of solid NaC_{18}, *v.* (50).

Hydrolysis

The values given are % hydrolysis according to the equation:

$$\% \text{ hydrolysis} = \frac{(N_w \text{ of } OH^-) \times 100}{\text{Total } N_w \text{ of soap}}$$

1. Hydrolysis by hydrogen electrode, neglecting diffusion potential (results too high in concentrated soaps) (80).

Soap	t, °C	N_w = 1.0	0.75	0.5	0.2	0.1	0.05	0.01	0.001
NaC_{16}	90°	0.2	0.27	0.38	0.55	1.3	5.5	6.6	
KC_{16}	90°	0.08	0.27	0.6	0.65	1.3	5.0	6.8	
NaC_{18}^{-}	25°	(55)				0.1(?)		0.6 (?)	4(?)

Hydrolysis.—(*Continued*)

$0.5N_w$ Soap at 90°

Soap	KC_{16}	KC_{14}	KC_{12}	KC_{10}	KC_8
% Hydrolysis	0.64	0.54	0.36	0.076	0.072

2. Hydrolysis by catalysis of nitrosotriacetonamine; values of 10^5N_v of OH^-. Results in concentrated soap probably low owing to sorption of amine.

NaC_{16} (65)	N_w =	0.042	0.5	0.8	1.0	0.46	0.1	
	t_y °C	90	90	90	90	70	70	
	$10^5N_vOH^-$	91	20	25	27	44	56	
KC_{16} (65)	N_w	90°	0.019	0.042	0.1	0.3	0.85	
	$10^5N_vOH^-$		76	93	93	58	11	
	N_w	70°	0.05	0.1	0.85	40°	0.051	30° 0.05
	$10^5N_vOH^-$		55	61	6		39	97
NaC_{18}^{-}, 90° (5)	N_w		0.002	0.01	0.02	0.05	0.1	
	$10^5N_vOH^-$		55	66	74	98	79	

Various Good Commercial Soaps at 90°; Values of 10^5N_v of OH^- (5)

x* =	1	0.5	0.1	x* =	0.5
Coconut oil	31	21	5	Washer	77
Olive oil	73	60	18	Tallow rosin	79
Toilet soap	76	60	24	Coal tar	82
Cold process	108	80	30	Shaving	94

* Grams soap in 100 cm³ solution at room temperature.

3. Hydrolysis by indicator method. Comparison of the color given an indicator in a pure soap solution with that of standard buffer solutions. Buffers were Sörensen and Palitzsch's glycine/NaOH and borax/boric acid. Indicators were Alizarin yellow G for 0.003 to $0.0005N_w$ OH^-; phenolphthalein for 0.0008 to $0.0001N_w$ OH^-, and for extremely dilute soap, phenol red. The myristic acid used was impure. Indicator was added in amount to produce the maximum color (73).

Soap	t, °C	Values of N_w of Soap									
		0.5	0.2	0.1	0.05	0.02	0.01	0.005	0.002	0.001	0.0_35	0.0_31
NaC_{12}	90	0.6	1.0	1.4	1.8	2.4	2.1	1.6				
	20	0.2	0.6	0.9	1.4	1.4	1.7	1.4				
KC_{12}	90	0.7	1.2	1.6	2.2	1.6	2.4	Also 0.35 at N_w = 0.86				
	20	0.17	0.50	0.70	1.4	1.2	1.9	Also 0.12 at N_w = 0.86				
NaC_{14}	90		0.56	1.11	2.2	3.85	4.3	Also 0.23 at N_w = 0.4				5.0
KC_{14}	90		0.56	1.1	1.6	1.75	2.9	1.8 Also 0.3 at N_w = 0.4				
KC_{16}	90	0.20	(1.0)	1.6	3.1	4.8	6.7	9.7		12.4	19.1	
	20						14				51	
NaC_{16}	90	0.2	(1.1)	1.6	1.6	4.1	7.0	8.0	15.5	15.8	18	
	20								35	27	68	
NaC_{18}	90	0.2	0.5	0.9	3.0	(6.0)	12		35			
	20							13.2				
KC_{18}	90		0.76	1.55	3.3	(8.6)	(15)	(20)	(50)	67	68	
	20										60	
NaC_{18}^{-}	90		0.41	0.85	2.0	5.0	8.5	(10.1)	(21)	24	16	
	20			0.24	1.6	2.7	4.5	6.3	16.1	24	28	
KC_{18}^{-}	90	(0.2)	0.7	1.5	2.9	5.9	6.9	9.2		18	16	
	20	(0.01)	0.08	0.2	1.4	3.8	2.0	5.9		23	28	
NaC_{22}	90		3.4	6.8	13.6	32.5	27					
			Jelly		Viscous liq.		Clear					
	20		45 (Viscous liq.)				68 (milky liq.)					

NaC_{16} and KC_{18}^{-} with excess of fatty acid, *v.* (75). Other determinations with various soaps and with added material, *v.* (50, 52, 55, 65, 67, 75, 76, 80, 112).

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INTERNATIONAL CRITICAL TABLES

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Volumes I to V Inclusive

Explanation.—For properties of natural and industrial materials of more or less indefinite chemical composition, look under the class of material. For properties of chemical substances and mixtures of definite composition, look under the property.

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II. The Liquid (Including Vitreous) State.—(*Continued*)

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III. The Crystalline State

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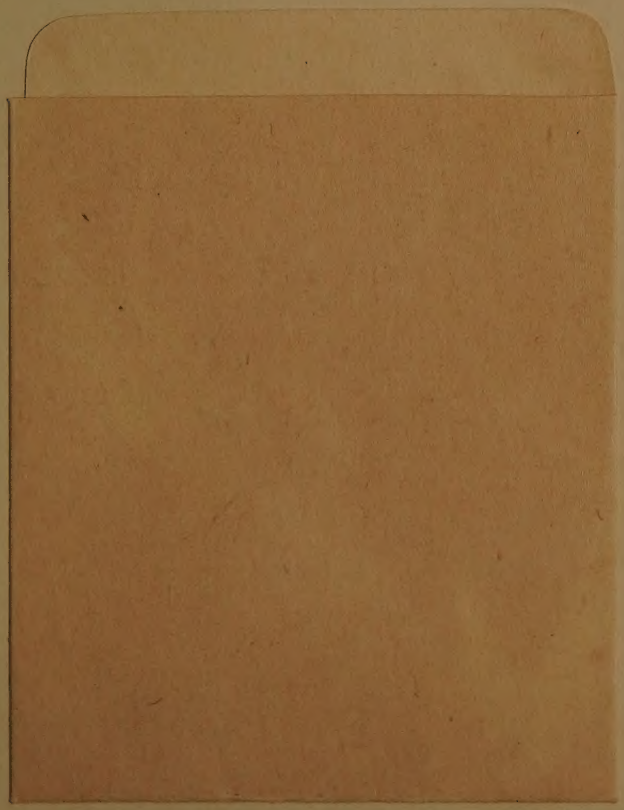

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